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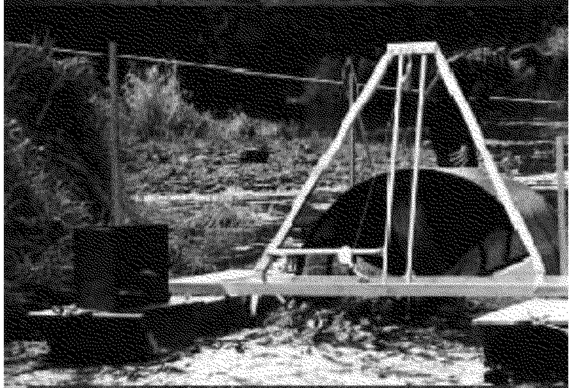


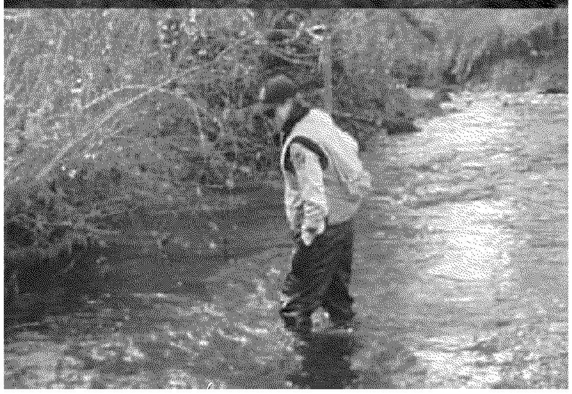

The Status and Trend of Physical Habitat and Rearing Potential in Coho Bearing Streams in the Oregon Coastal Coho Evolutionary Significant Unit

Report Number: OPSW-ODFW-2009-5

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K. J. Anlauf, K. K. Jones and C. H. Stein
Corvallis Research Lab
Oregon Department of Fish and Wildlife
28655 Highway 34
Corvallis, Oregon 97333

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INTRODUCTION

In 1997, the Oregon Coastal Restoration Initiative (OCSRI 1997) identified the quality of stream habitat as a potential factor influencing the decline of coho salmon (*Oncorhynchus kisutch*) in Oregon coastal streams. In 1998, the Oregon Department of Fish and Wildlife (ODFW) implemented a monitoring program that utilized a random, spatially balanced survey design to provide statistically rigorous information on the status and trend of habitat conditions in Oregon coastal streams. In response to the ESA listing of coho salmon, the State of Oregon published a comprehensive review of aquatic habitat in the Oregon Coastal Coho Evolutionary Significant Unit (ESU) in 2005 (Rodgers et al 2005). The NOAA Fisheries more recently published a request for additional information in the 2009 Federal Register notice (Federal Register / Vol. 74, No. 81 / Wednesday, April 29, 2009). This report will serve as an update to Rodgers et al (2005), and will provide an analysis of the current status and trends in aquatic habitat from 1998 through 2008 within the Oregon Coastal Coho ESU.

The status and trend of instream physical habitat conditions in the Oregon Coastal coho ESU were assessed from twelve variables collected by the ODFW habitat monitoring program from 1998-2008. Habitat conditions were described at the scale of the ESU, four monitoring areas/strata within the ESU, and by six land use categories (agriculture, urban, private non-industrial and industrial forest, and public state and federal forest). The condition of habitat was compared among monitoring areas and land use categories. In addition, the habitat condition at random survey sites was compared to that at sites experiencing minimal human disturbance (i.e. reference sites).

Potential winter rearing capacity for juvenile coho salmon was calculated for all available habitat and for high quality habitat at the monitoring area scale and in selected population units. We calculated the rearing potential from high quality habitat because modeling (Nickelson and Lawson 1998) demonstrated that during periods of prolonged poor ocean survival, only areas with high quality habitat will be able to support coho at full seeding during poor marine conditions. The final objective of this report is to discuss whether sufficient habitat capacity exists to support productivity of juvenile coho at the monitoring strata scale during periods of low marine survival.

METHODS

In this report, the status and trend of habitat conditions in the ESU are based on variables related to the quality of aquatic habitat for coho (Table 1). The variables describe stream morphology, substrate composition, instream roughness, riparian structure, and winter rearing capacity for juvenile coho. Winter rearing capacity is an integrated variable that emphasizes the percent of pools, complexity of pools, and amount of off-channel and beaver pools. Limited rearing occurs in fast-water stream habitats during the winter. Data were collected during surveys from 1998-2008. Habitat conditions are described at the scale of the Oregon Coastal coho ESU and for each of the four monitoring areas within the ESU (Figure 1). Sites were also post-stratified and analyzed by land use category. We used the same 124 reference sites as reported in Rodgers et al. (2005) and Anlauf and Jones (2007) for comparisons to streams in settings that experience minimal human influence.

ODFW habitat surveys are designed to assess habitat in all "wadeable" streams within the distribution of coho in the ESU. The sample frame was derived from 1st through 3rd order coho bearing streams depicted on a 1:100,000 scale digital hydrography layer developed by USGS (1998-2006) and on a 1:24,000 scale layer modified by ODFW (2007-2008). Streams above barriers that block adult coho passage were removed from the selection frame. A generalized random-tessellation stratified (GRTS) design (Stevens and Olsen 2004) was used to select potential sample sites from the candidate stream reaches in each monitoring area. The GRTS selection protocol results in a pool of random, spatially balanced sites across the landscape, thereby reducing potential site selection bias. The selection protocol incorporated a panel design in which 25% of the sites were surveyed annually, 25% every three years, 25% every nine years, and the remaining 25% were unique each year. The first two panels were used in trend detection.

Habitat surveys were conducted as described by Moore et al. (2008) with the modification that survey lengths are restricted to 1,000 m per site and all habitat unit lengths and widths are measured rather than estimated. Using this methodology, a total of 621 unique sites were surveyed in the ESU from 1998-2008 (Table 2; Figure 2). Roughly 10 percent of the sites per year in each monitoring area are resurveyed by a separate two-person crew to measure variation within season and between crews.

Site Weighting

Previous analyses indicated differences in habitat quality by land use (Rodgers et al. 2005). In theory, the GRTS site selection process should provide a list of candidate sample sites that are representative of land use. However, due to a higher rate of access denial to private lands compared to public lands (Rodgers et al 2005), a bias may exist in our "random" survey data because land use types are not represented in proportion to their occurrence. To reduce this potential bias, we re-apportion site weights based on land use through the following steps: 1) site land use was stratified into one of six categories using a GIS coverage developed by the Oregon Department of Forestry (L. Dent, personal communication); 2) the number of coho stream miles within each ownership class and monitoring area was determined by overlaying a 1:24k digital coho distribution layer on the land use coverage; 3) the number of sites sampled within each land use class was totaled for each monitoring area; 4) the final site weight was determined by dividing the number of sites within each land use class into the number of stream miles for that class. The primary assumption we made when weights were adjusted was that the sampled sites were representative of the non-sampled sites. However, there was no way to test the validity of this assumption.

Winter Rearing Capacity

We used the Habitat Limiting Factors Model (HLFM version 7.0) to estimate the capacity of aquatic habitat to support juvenile coho during the winter. The background, scientific basis, and application of the HLFM are described in Reeves et al (1989), Nickelson et al. (1992), Nickelson (1998), and Nickelson and Lawson (1998). Since the publications in 1998, two major adjustments have been made to the model. The first (version 6) reduced the potential density that large streams could support. The second modification (version 7) recognized the role that large complex jams could play in providing refugia for juvenile coho during the winter, effectively increasing the carrying capacity of a stream. The two adjustments to the model were based on data collected during the studies referenced above, and ongoing studies within the coastal coho ESU (e.g. Jepsen and Leader 2008) (T. Nickelson, personal communication).

Most of our surveys were conducted during the summer; however, 253 of the 621 sites were surveyed during the winter. For sites surveyed during the winter, we used the actual modeled estimate. For the other 368 sites, we estimated the winter capacity based on the summer surveys. To estimate winter habitat conditions at sites surveyed only in the summer, we developed a predictive model based on the relationship between summer and winter habitat conditions at 290 sites that were surveyed in both seasons. Comparisons and estimates were made from sites at which we conducted revisits during the summer and winter. We used two datasets to address our questions, (1) Sites that were sampled across the four monitoring areas in 1999-2003 and in 2007-2008 (n=218), and (2) sites that were sampled across four coho salmon population areas during summer 2003-2006 and then revisited in winter 2007 (n=72). To assess our ability to use summer habitat data to estimate the carrying capacity during the winter we compared estimates of winter parr calculated from summer habitat data (referred to here as summer parr/km) with estimates calculated using winter habitat data (referred to here as winter parr/km). We excluded 16 sites so they would not bias the regressions (studentized residuals greater than 2 in absolute value). In general these were sites with a high percentage of alcoves/beaver pools during the summer but not the winter which resulted in unbalanced parr estimates.

We fit a linear regression model with winter parr/km as the response and summer parr/km as the predictor to address how well summer habitat data predicts winter parr. We then assessed several habitat covariates, developing appropriate model combinations and then used AIC (Akaike Information Criterion) to select the best model. The model with the lowest AIC was deemed more desirable (Burnham and Anderson 2002). Summer parr/km, active channel width (ACW), percent scour pools, percent complex pools (LP3), and percent alcove/beaver pools (ALBP) was selected as the best model based on AIC values and explained slightly more variation in winter parr rather than summer parr alone ($R^2 = 0.879$). The final model is:

Winter Parr = (23.52293*ACW) - (6.66189*A LBP) + (5.86348*Scour Pools)-(29.99797*LP3 Pools) + (0.70327*Summer Parr)

We estimated the winter carrying capacity of each monitoring strata by summing the predicted estimates of each surveyed site multiplied by site weight and adjusted by land use as described in the summer habitat section. Estimates of smolt capacity in eight population units were based on winter surveys within the respective population frame. The winter survey data were also used to improve the estimates at the strata scale. High quality habitat was considered to be able to support 1,850 parr per kilometer.

Status and Trend Analytical Methods

S-PLUS 7.0 (Insightful Corporation) programs written by the U.S.E.P.A. were used to determine weighted values and variance for the mean, median, and percentiles. More information on these S-Plus programs may be obtained at: (http://www.epa.gov/nheerl/arm/anal ysispages/techinfoanalysis.htm)

To compare stream conditions at the random sites to conditions at reference sites, we combined all years of random surveys according to spatial scale or land use category. Sites with multiple years of survey data were averaged to provide one estimate per site. The point of comparison for each variable was based on the 25th and 75th percentile of the reference conditions, here termed low, moderate, and high.

We estimated the average annual change (trend) in seven aquatic habitat variables within each of the four monitoring area/strata within the coastal coho ESU and determined the probability of detecting that change. To do this, we modified a model proposed by VanLeeuwen et al. (1996) and estimated linear trends across the 11 year time frame (1998-2008, excluding 2004) within the distribution of coho salmon. We used sites from the annual and three year panels and modeled the habitat and parr response variables as a monitoring area specific linear function of time. We accounted for four different components of variation attributable to year-to-year effects, site-to-site effects, site-by-year effects, and residual variation in habitat conditions. We fit separate regression models to the data for each of the four monitoring areas and performed separate analyses for each habitat and parr response variable. Some of the response variables were transformed so we could model more normal distributions. Once we found the functional form of the model, we tested whether (a) there was a trend in a habitat or parr response variable and (b) whether the trend varied among the different monitoring areas. In the event that we did not find a statistically significant trend, we compared the intercepts and the adjusted means across monitoring areas. For more specific details on these analyses, see Anlauf & Gaeuman (In Review).

In order to determine our probability to detect a change (power) in habitat conditions with these statistical models, we refer to a previous analysis that used 1,000 simulated data sets representing all annual and three year sites surveyed across all habitats for a 10 year period, across five Oregon Coastal monitoring areas (four coastal coho monitoring areas and one southern Oregon northern California coho monitoring area) (Anlauf &

Gaueman, In Review). The power of a statistical test is the probability of rejecting the null hypothesis when the alternative is in fact true. Power in this case equals one minus the Type II error and is also known as sensitivity or the true positive rate. We looked at detection rates for monitoring periods of 5, 10, and 15 years. The variance component estimates used in the simulations were obtained from the analysis of the wood volume (log transformed) data with site = 1.58, year = 0.01, site x year = 0.08, and residual = 0.22 (total variance = 1.89). The intercept term, averaged over the five estimated intercepts from the wood volume model, was 2.6 (Anlauf & Gaueman, In Review).

RESULTS

Status of Aquatic Habitat

The data are presented in tabular form (Tables 3 and 4), and in box and whisker plots showing medians, 25% and 75% quartiles, 5% and 95% range, and outliers (Figures 3-11). Cumulative distribution frequencies of each variable by strata and land use are provided in the appendices.

Channel Morphology

Features that describe channel morphology include the amount of pool habitat, the number of deep pool, the amount of slack water pools (e.g. beaver ponds, alcoves, dam pools), and the amount of secondary channels. The Mid-South Coast ranks highest in pools, deep pools, and slackwater pools. The Umpqua ranks the lowest in terms of these three attributes. The North Coast has the highest amount of secondary channel with 29% percent of its streams having greater than 5.3% area in secondary channel. All the monitoring areas have more pool habitat than the reference streams on average.

The land use categories reflect land management and location within a stream drainage. Public lands (federal and state forest) and private industrial forest tend to be high in the watersheds, and private non-industrial forest, agriculture, and urban lands tend to be low in the drainage system. The channel morphology attributes are related to stream size and processes, and to management of the landscape. Compared to other land uses, streams flowing through agricultural lands have more pool and slackwater habitat. Federal and state forests have the least amount of pool habitat, reflecting their relatively high location in watersheds.

Instream Roughness

Large wood provides the majority of instream roughness in coastal coho streams. The North Coast has the highest number of pieces and largest volume of wood in streams. The Umpqua ranks the lowest of pieces and volume of large wood. All monitoring areas are low in key pieces of wood relative to reference conditions.

Federal, state, and private industrial forests have the highest amount of large wood relative to other land uses. However, all are low in volume and the number of key pieces relative to reference streams. Compared to other land uses, streams flowing through agricultural and urban have the lowest levels of wood pieces, volume, and key pieces.

Substrate

The Mid-South monitoring area tends to have the highest amount of fine sediment relative to other monitoring areas. The amount of gravel in the Mid-South Coast, Mid-Coast, and North Coast is similar to reference streams. Notably, the Umpqua has lower levels of gravel and higher levels of bedrock than other monitoring areas. The North Coast and Mid-South Coast have the lowest levels of bedrock. All the monitoring areas have fine sediment accumulations higher than in reference streams.

Relative to other land uses, streams flowing through agricultural and urban lands have the highest levels of fine sediment in riffles and the lowest levels of bedrock. Federal forest streams have the lowest levels of fine sediment in riffles, and are similar to reference streams. Federal and private non-industrial forest streams have the most bedrock compared to other land uses.

Riparian Structure

Riparian trees provide high levels of shade in coastal streams. The median value of was approximately 80% shade in all monitoring areas, although the North Coast, Mid-South Coast, and Umpqua had a high percentage of streams in the low category. The riparian zones in all monitoring areas did not contain many large conifer trees relative to reference streams.

Variation among land use categories was large. Shade levels were low in agricultural and urban land uses, with a majority of the streams in the low category. Shade was highest in forested landscapes. The number of large conifers in agricultural and urban land uses was extremely low, and few streams were in the high category among any land uses types.

Winter Rearing Capacity

Winter rearing capacity was generally low in all monitoring areas, with more than 50% of the streams in the low category. The lowest winter rearing potential for juvenile coho was in the Umpqua, followed by the Mid-South Coast area. However, the Mid-South had a number of sites with high capacity which raised the mean value. The percent of streams in the high capacity category ranged from 8 % in the Umpqua to 18% in the Mid-Coast monitoring area. The spatial distribution of high quality sites varies within each monitoring area (Figure 12).

The highest rearing potential among land uses was on private industrial forest land. This corresponded with a high percent of pool habitat, slack water pools, and large wood.

Urban and agricultural lands hand the lowest capacity for winter rearing habitat. Federal and state forest land had a moderate capacity of winter rearing habitat, but were limited by the amount of pool habitat available.

Estimates of winter rearing potential at the strata and population scales are provided in Table 5. The amount of high quality rearing habitat at the monitoring strata scale ranges from 8% (Umpqua) to 21% (the other three strata) of the stream miles. At the population scale, the high quality habitat ranges from a low of 9% in the South Umpqua to 29% in the Nehalem and Siuslaw populations. However, the high quality miles would be responsible for 26%, 61%, 64%, and 80% of the production from the Umpqua, Mid-South Coast, Mid-Coast, and North Coast strata respectively. The HLFM model suggests that the high quality habitat can support a majority of the parr, much greater than the percent of stream miles might indicate. If ocean survival (smolt to adult) were 3% (low marine survival as defined in the Coastal Coho Conservation Plan (ODFW 2007)), the number of potential adult coho returning to Oregon rivers would total 428,208 fish, ranging from 80,061 in the Umpqua to 160,402 in the North Coast monitoring strata (Table 5). Of the eight populations, the Alsea would produce the lowest number of adults at 9,999 and the Nehalem the highest number at 102,970. The high quality habitat would be responsible to 39% (Alsea) to 84% (Tillamook) of the production potential from each population.

Trend Analysis

Variance partitioning

The relative proportions of total variance attributed to each component were similar among all of the habitat variables (Figure 13). Site-to-site variation vastly dominated the variance proportions for each of the habitat attributes. Temporal variability was minimal relative to the spatial variability for all variables, ranging from 0.56 – 1.72 % for the year component and 2 – 23 % for the site-by-year interaction component. The remaining residual variation ranged from 9 – 31% with pool frequency having the highest proportion of residual error. This variable also had the highest proportion of the total variance associated with the year-by-year and site-by-year interaction components relative to the other habitat attributes.

Trend model

Linear trends were detected in four of the seven habitat/parr response variables in at least one of the four monitoring strata (wood volume, percent sand/organics, percent gravel, winter parr per km) (Table 6; Figure 14); trend was significant in 6 of 28 possible variables (7) and monitoring strata (4) combinations. A positive estimated trend of 0.08 log parr/km was detected in the Mid-South Coast monitoring area for winter parr/km, per year for the 11 year monitoring period. For wood volume, a linear decrease of -0.06 log (m3/100 m) per year was detected in the North Coast region. We also noted linear trends among fine sediment and gravel percentages with an estimated decrease of 1.63% in the North Coast and 1.64% increase in the Mid-South Coast for fine sediment, and an estimated increase of 1% in the North Coast and 0.9% decrease in the Mid-South Coast for gravel.

Note that trend estimates on the log scale translate directly into estimated multiplicative, as opposed to additive, effects in terms of the original units. The distribution of data by year for all variables is presented as boxplots in Figures 15 – 22.

There was insufficient evidence to suggest a linear trend in any of the four monitoring areas for three of the habitat variables (percent of pools, pool frequency, and riffle gravel) in any monitoring area.

Simulations and power analysis

The results of the simulations indicate that the probability of detecting a trend in the response variable increased with monitoring period (5, 10, or 15 years), and with the size of the hypothesized trend (1 or 2%). Our ability to detect a 1 or 2% trend in 5 years was 15% (± 1.1%) and 28% (± 1.4%). Our ability to detect a 1 or 2% trend in 10 years was 51% (± 1.6%) and 98% (± 0.4%). Finally, our ability to detect a 1 or 2% trend in 15 years was 94% (± 0.8%) and 100% (± 0.0%). We found that our ability to detect trends in habitat conditions is sensitive to the proportion of year-to-year variance (Anlauf & Gaueman, In Review).

DISCUSSION

Streams within the coho ESU are pool rich, but structurally simple. The amount of pool habitat is high within all monitoring areas in the ESU, although the amount of slow water and off-channel habitat is limited. Compared to conditions in streams with minimal human disturbance, amounts of large wood are low in all monitoring areas. In addition, amounts of fine sediment are higher than reference conditions. The lack of large wood and relatively high amount of fine sediment was evident across all land use types. The only exception was that the levels of fine sediment in streams on public land were comparable to reference conditions. Although habitat conditions differ by land use category, the variation is, in part, an effect of watershed position and geomorphology.

The high amount of overall pool habitat, but general lack of off-channel or complex pools is reflected in the evaluation of habitat capacity to support juvenile coho during the winter. The mean values of rearing capacity are moderate (except for the Umpqua), but the median values are all low. This indicated that the majority of the streams are not highly productive for juvenile coho, but that a smaller percentage of high quality stream reaches potentially support a disproportionate amount of the rearing capacity. The high quality reaches were not evenly dispersed through all population units and monitoring strata. For example, the Nehalem population unit in the North Coast monitoring strata has much higher rearing capacity than the Tillamook population unit, and similarly the Siuslaw has a higher average capacity than the Alsea.

Estimates of the potential adult production at low marine survival (3%) indicate a coastwide escapement of 450,000 adult coho, of which 63% is accounted for by high quality habitats. Both high quality and other stream habitat are responsible for the coastwide production. Although the amount of high quality habitat is low in the Umpqua strata, the potential escapement at low marine survival is approximately 80,000 adults should all the habitat be fully seeded, and over 20,000 adult coho if only the high quality habitat fully seeded.

Values of high quality miles and rearing capacity in this report are slightly higher than reported in Rodgers et al (2005). This may be an effect of 1) using an updated HLFM model that incorporates the productivity benefit afforded by large wood in pools, 2) using only sites from probability sampling, and 3) incorporating more recent surveys during the winter to better assess habitat conditions during this critical period. In addition, the influence of habitat protection and number and higher quality habitat restoration projects may have started to have an effect at the monitoring strata scale.

Previous (Jacobsen et al. 2007) and current (Tippery et al. in prep) evaluations of habitat restoration projects have shown positive effects from large wood treatments. Though the number of miles treated is low relative to the rearing distribution of coho, the projects are beginning to improve habitat in reaches and streams that have high rearing potential. In particular, the projects that have been in place for five years show an overall increase in pool habitat and complex pool habitat, higher wood amounts, and improved substrate characteristics. Most importantly, the increase in habitat complexity is reflected in increase winter rearing capacity for juvenile coho at the restoration sites (Tippery et al. in prep).

The trend in habitat conditions and parr capacity was evaluated for an 11-year period from 1998-2008. The range of values for each habitat variable was considerable, influenced by geomorphic setting, and the natural and anthropogenic history of each stream. However, because the variance was dominated by the site-to-site component, we were able to detect small, but significant trends over the eleven-year period in several habitat variables at the monitoring strata scale. For example, the Mid-south coast strata had a significant positive increase in winter rearing capacity for juvenile coho. For the most part, at the ESU and monitoring strata scales, the habitat has not changed significantly during the past decade. The combination of habitat protection and active restoration may have reversed the downward trajectory in habitat conditions. Though we were able to detect small trends (1-2%) over the 11 year period, the variation in habitat conditions was high across the landscape and our sample size is small. Additional years of sampling will continue to improve our detection capabilities. The power simulation suggests that we will have close to a 100% ability to detect 1-2% linear trends with 15 years of sampling given the current variance structure afforded by the survey design and field protocols.

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Table 1. Definition of habitat survey parameters evaluated for this report.

Decline Factor	Parameter	Definition
Channel morphology	% Pools*	% Channel area represented by pool habitat
Channel morphology	Pools per 100 meters*	Average number of pools per 100 meter of stream
Channel morphology	% Secondary Channel	% Total channel area represented by secondary channels
Channel morphology	% Slackwater Pools	% Primary channel area represented by slackwater pool habitat (beaver pond, backwater, alcoves, isolated pools).
Channel morphology	Deep Pools/km	Pools > 1m deep per kilometer of primary channel
Substrate	% fines in riffles	Visual estimate of substrate composed of <2mm diameter particles in riffle habitat units
Substrate	% fines in reach*	Visual estimate of substrate composed of <2 mm diameter particles in riffle habitat units
Substrate	% gravel in riffles*	Visual estimate of substrate composed of 2-64mm diameter particles in riffle habitat units
Substrate	% gravel in reach*	Visual estimate of substrate composed of 2-64 mm diameter particles in all habitat units
Substrate	% bedrock in stream	Visual estimate of substrate composed of solid bedrock
Instream roughness	Pieces LWD/100m	# pieces of wood ≥ 0.15m diameter X 3m length per 100 meters primary stream length
Instream roughness	Volume LWD/100m*	Volume (m^3) of wood ≥ 0.15m diameter X 3m length per 100 meters primary stream length
Instream roughness	Key Pieces LWD/100m	# pieces of wood ≥ 60 cm diameter & ≥ 12 meters long per 100 meters primary stream length
Riparian Structure	# conifer trees>50cm dbh	# of conifer trees larger than 50cm diameter within 30m of the stream channel in a 300m length reach
Riparian Structure	% shade	The amount of vegetative and topographic shade over the stream channel expressed as a percent
Winter rearing capacity	# parr/km*	The potential capacity of the stream to support juvenile coho during the winter

*Variables used in trend analysis

Table 2. Total number of candidate sites surveyed, not surveyed, and compiled in the original annual sample draw by year and within four Monitoring Areas in the Oregon Coastal coho ESU, 1998-2008.

Monitoring Area	**Status**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
North Coast	Sites surveyed	41	49	45	41	46	45	22	39	41	42	35
	Sites not surveyed	8	7	7	6	9	9	4	9	3	10	10
	Total no. sites in sample draw	49	56	52	47	55	54	26	48	44	52	45
Mid-Coast	Sites surveyed	41	37	40	41	38	39	17	47	43	41	37
	Sites not surveyed	16	15	12	12	11	13	6	3	3	11	12
	Total no. sites in sample draw	57	52	52	53	49	52	23	50	46	52	49
Mid-South Coast	Sites surveyed	34	45	36	36	40	36	19	42	37	32	33
	Sites not surveyed	27	13	19	16	15	17	7	7	9	20	12
	Total no. sites in sample draw	61	58	55	52	55	53	26	49	46	52	45
Umpqua	Sites surveyed	38	41	36	38	39	43	27	35	40	40	45
	Sites not surveyed	12	7	15	11	16	12	2	11	8	12	7
	Total no. sites in sample draw	50	48	51	49	55	55	29	46	48	52	52
	TOTAL SURVEYED	154	172	157	156	163	163	85	163	161	155	150
	TOTAL NOT SURVEYED	63	42	53	45	51	51	19	30	23	53	41
	TOTAL IN SAMPLE DRAW	217	214	210	201	214	214	104	193	184	208	191

Table 3. Key habitat attributes relative to reference conditions in coastal ESU and strata. The reference values (low and high) refer to the 25th and 75th percentile of values in those streams.

Habitat attribute:	Coastal Reference (n=124)	ESU (n=621)	North Coast (n=182)	Mid Coast (n=198)	Mid-South (n=124)	Umpqua (n=117)
		STRATA				
Percent pools	Low <19%	23	25	23	17	28
	Moderate	32	37	30	22	33
	High >45%	45	38	47	61	39
	Mean	43	39	44	51	38
	Median	38	33	41	56	32
Pools >1m deep per km	Low 0	37	31	34	28	45
	Moderate	37	38	43	32	34
	High >3	27	31	23	40	21
	Mean	2	2	2	3	2
	Median	1	1.4	1.0	2.0	0.8
Percent slack water pools	Low 0%	30	22	33	25	35
	Moderate	49	54	39	46	54
	High >7%	21	24	29	30	11
	Mean	8	9	9	10	4
	Median	1	0.7	0.6	1.1	0.4
Percent secondary channel	Low <0.8%	33	4	7	9	12
	Moderate	47	67	76	73	70
	High >5.3%	20	29	18	18	19
	Mean	4	5.1	3.3	4.1	2.9
	Median	2	3	2	2	1
Percent fines in riffles	High >22%	35	38	34	42	40
	Moderate	44	37	45	38	39
	Low <8%	21	25	21	20	21
	Mean	22	24	22	29	17
	Median	16	16	16	20	13
Percent gravel in riffles	Low <26%	28	22	18	27	38
	Moderate	49	59	51	44	43
	High >54%	24	19	30	29	19
	Mean	39	39	43	41	35
	Median	39	39	43	43	34
Percent bedrock	High >11%	38	26	37	30	50
	Moderate	37	44	40	31	35
	Low <1%	25	30	23	39	15
	Mean	13	7	12	10	19
	Median	7	4	6	3	11

Pieces LWD/100m	Low <8	43	28	33	49	57
	Moderate	44	47	54	36	38
	High >21	13	24	13	15	5
	Mean	12	16	12	11	9
	Median	9	14	10	8	7
Volume LWD/100m	Low $<17m^3$	68	58	59	74	77
	Moderate	29	36	37	23	22
	High $>58m^3$	3	6	3	4	2
	Mean	16	22	18	15	12
	Median	11	15	14	9	8
Keypieces LWD/100m	Low <0.5	66	62	56	75	72
	Moderate	31	33	41	21	26
	High >3	3	5	3	4	2
	Mean	1	0.8	0.7	0.5	0.4
	Median	0	0.3	0.4	0.2	0.2
Conifers >50cm dbh per 1000ft.	Low <22	66	66	60	70	70
	Moderate	31	32	35	30	27
	High >153	3	2	4	1	3
	Mean	30	26	35	23	32
	Median	17	17	18	10	10
Percent shade	Low <76%	38	39	31	45	38
	Moderate	40	39	49	32	40
	High >91%	22	23	21	23	22
	Mean	77	78	80	73	77
	Median	81	81	82	80	79
Winter parr per km	Low <900/km	58	52	55	62	62
	Moderate	28	32	27	22	30
	High >1850/km	14	16	18	16	8
	Mean	1164	1453	1240	1413	806
	Median	668	829	820	618	538

Table 4. Key habitat attributes in different land uses relative to reference conditions in the coastal ESU. The reference values (low and high) refer to the 25th and 75th percentile of values in those streams.

		LAND USE					
Habitat attribute :	**Coastal Reference** (n=124)	**Agriculture** (n=73)	**Federal Forest** (n=160)	**Private Industrial Forest** (n=205)	**Private Non-Industrial Forest** (n=72)	**State Forest** (n=78)	**Urban** (n=18)
Percent pools	Low <19%	16	35	17	15	31	16
	Moderate	21	30	41	34	41	22
	High >45%	63	35	43	51	28	63
	Mean	53	35	43	46	35	51
	Median	60	30	38	47	32	57
Pools >1m deep per km	Low 0	32	49	36	21	27	37
	Moderate	39	29	38	45	42	42
	High >3	29	22	26	34	31	20
	Mean	2	2	3	2	3	2
	Median	1	0	1	2	2	1
Percent slack water pools	Low 0%	32	37	23	23	28	39
	Moderate	36	51	56	53	47	43
	High >7%	32	12	21	24	25	18
	Mean	11	5	8	7	8	9
	Median	1	0	1	1	1	1
Percent secondary channel	Low <0.8%	12	6	5	8	2	8
	Moderate	74	71	76	76	63	80
	High >5.3%	13	24	20	16	34	12
	Mean	5	3	4	3	4	3
	Median	1	2	2	2	3	0
Percent fines in riffles	High >22%	58	23	31	29	31	53
	Moderate	26	54	48	47	44	13
	Low <8%	16	23	21	25	26	34
	Mean	29	17	23	20	21	31
	Median	24	15	16	14	15	22
Percent gravel in riffles	Low <26%	24	24	32	28	26	31
	Moderate	49	57	42	40	57	40
	High >54%	26	19	25	32	17	30
	Mean	42	38	38	40	37	43
	Median	46	37	38	43	35	39
Percent bedrock	High >11%	31	44	36	48	34	28
	Moderate	35	42	39	24	46	29
	Low <1%	34	14	24	28	21	43
	Mean	11	15	13	16	11	8
	Median	4	9	6	10	5	1

Pieces LWD/100m	Low <8	74	30	34	51	25	83
	Moderate	24	57	49	43	44	17
	High >21	2	13	17	6	31	0
	Mean	6	13	14	9	16	5
	Median	6	12	11	8	15	4
Volume LWD/100m	Low $<17m^3$	96	51	63	77	51	100
	Moderate	4	43	33	23	44	0
	High $>58m^3$	0	6	4	0	5	0
	Mean	5	24	18	10	23	4
	Median	4	17	13	8	17	3
Keypieces LWD/100m	Low <0.5	95	42	67	69	59	100
	Moderate	5	52	30	31	37	0
	High >3	0	6	4	0	4	0
	Mean	0	1	1	0	1	0
	Median	0	1	0	0	0	0
Conifers>50cm dbh/1000ft.	Low <22	90	48	63	67	69	91
	Moderate	10	46	35	31	29	5
	High >153	0	6	2	2	2	4
	Mean	11	63	28	23	29	13
	Median	0	35	18	17	12	0
Percent shade	Low <76%	63	21	29	56	24	70
	Moderate	24	52	48	27	44	15
	High >91%	13	27	23	17	32	15
	Mean	65	84	81	73	82	64
	Median	66	86	83	75	85	68
Winter parr per km	Low <900/km	63	60	50	61	60	67
	Moderate	27	26	32	28	26	22
	High >1850/km	10	14	18	11	14	11
	Mean	1200	1946	1338	1114	1290	864
	Median	558	606	853	602	727	352

Table 5. Juvenile coho smolt production capacity from Habitat Limiting Factors Model (Version 7). Strata estimates are based on summer surveys at spatially balanced sample sites within the strata frame and winter surveys within each population frame. The number of adults assumes 3% ocean survival to the total smolt potential. Blank fields indicate lack of data.

Strata	High Quality Habitat (miles)	Total Habitat (miles)	Percent High Quality Habitat	High Quality Habitat Smolt Production	Total Smolt Production	Adults at 3% survival
North Coast	342	1417	21%	4,279,592	5,346,727	160,402
Mid Coast	378	1931	20%	2,482,273	3,853,608	115,608
Umpqua	207	2494	8%	701,009	2,668,694	80,061
Mid-South	272	1321	21%	1,878,327	3,071,235	92,137
Population						
Necanicum						
Nehalem	217	805	28%	2,755,840	3,432,329	102,970
Tillamook	47	373	13%	919,637	1,095,362	32,861
Nestucca	47	225	22%	458,651	590,744	17,722
Salmon						
Siletz						
Yaquina	36	201	19%	505,067	637,013	19,110
Beaver						
Alsea	37	353	11%	128,553	333,297	9,999
Siuslaw	208	752	29%	1,393,893	1,858,222	55,747
Lower Umpqua						
Middle Umpqua						
North Umpqua						
South Umpqua	105	1209	9%	352,567	829,894	24,897
Coos						
Coquille	178	675	27%	573,114	1,211,574	36,347
Floras						
Sixes						

Table 6. Trend estimates for selected habitat variables. Model output with slope estimates and standard errors p value ($\alpha = 0.05$), and upper and lower confidence limits around the slope estimate. The model fit also indicated. Asterisks indicate a significant trend detected.

Response	**Model Fit**	**MA**	**Estimate**	**SE**	**P-value**	**LowerCL**	**UpperCL**
Winter Parr per km (log)	Unequal Slope	NC	0.02341	0.02694	0.3912	-0.03141	0.07823
		MC	0.0129	0.02677	0.6334	-0.04165	0.06745
		MS*	0.08935	0.03128	0.006	0.02667	0.152
		UMP	-0.03059	0.03455	0.3788	-0.09944	0.03826
Wood Volume/100m(log)	Unequal Slope	NC*	-0.06741	0.02734	0.0223	-0.1242	-0.01059
		MC	0.04042	0.02693	0.149	-0.01575	0.09659
		MS	0.05834	0.03068	0.0661	-0.0041	0.1208
		UMP	0.00278	0.03347	0.9342	-0.0647	0.07026
Percent Sand/Organics	Unequal Slope	NC*	-1.6329	0.3553	<0.0001	-2.3571	-0.9088
		MC	-0.07912	0.3496	0.8225	-0.7941	0.6359
		MS*	1.6434	0.4073	0.0002	0.8258	2.461
		UMP	-0.09928	0.4484	0.8255	-0.9954	0.7968
Percent Gravel	Unequal Slope	NC*	1.0838	0.3572	0.0048	0.3557	1.812
		MC	-0.1156	0.3479	0.7422	-0.8285	0.5974
		MS*	-0.9675	0.4179	0.0244	-1.8052	-0.1298
		UMP	0.29	0.4592	0.5298	-0.6265	1.2066
Percent Pools	Common Slope	All MA	0.882	0.4418	0.0806	-0.1351	1.899
Pools/100m(log)	Common Slope	All MA	0.008928	0.012	0.4756	-0.01818	0.03604
Riffle Gravel	Common Slope	All MA	0.09325	0.2876	0.746	-0.4727	0.6592

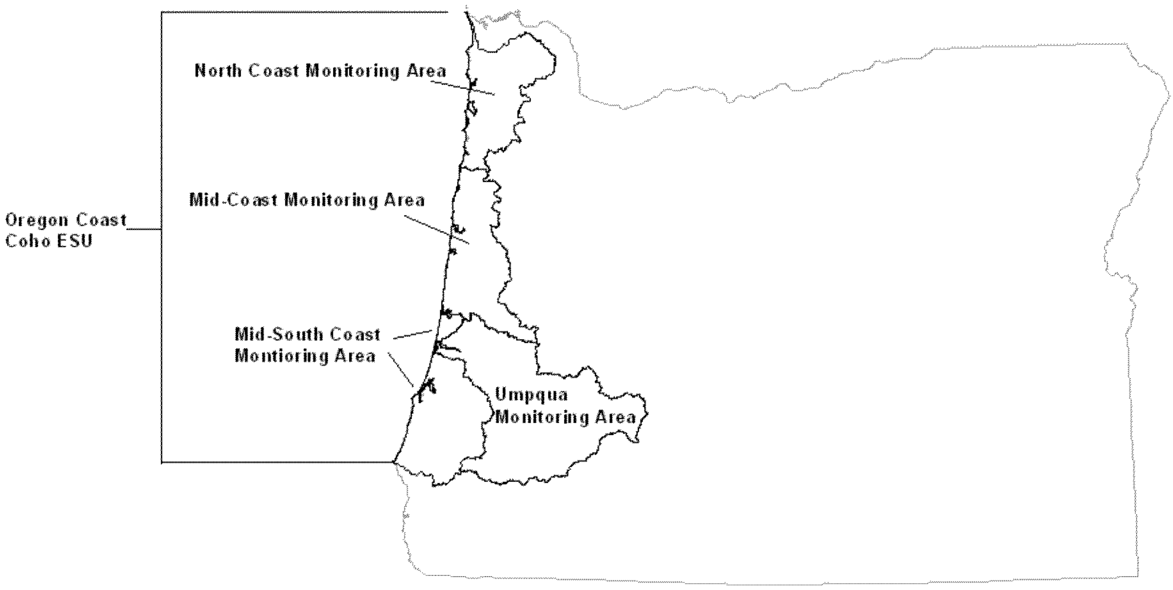


Figure 1. Location of four monitoring areas in the Oregon Coastal coho ESU.

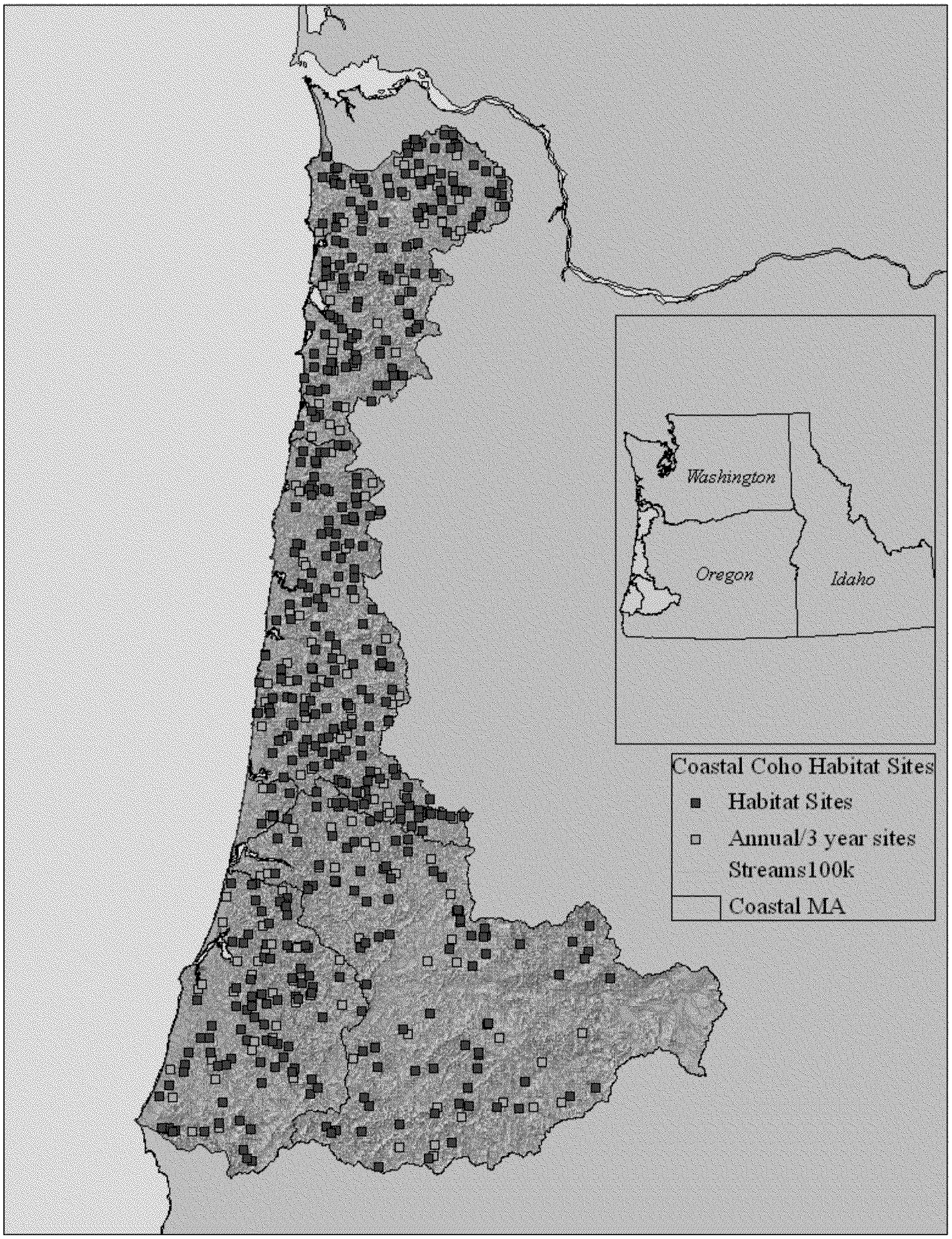


Figure 2. Location of 621 random sites surveyed from 1998-2008.

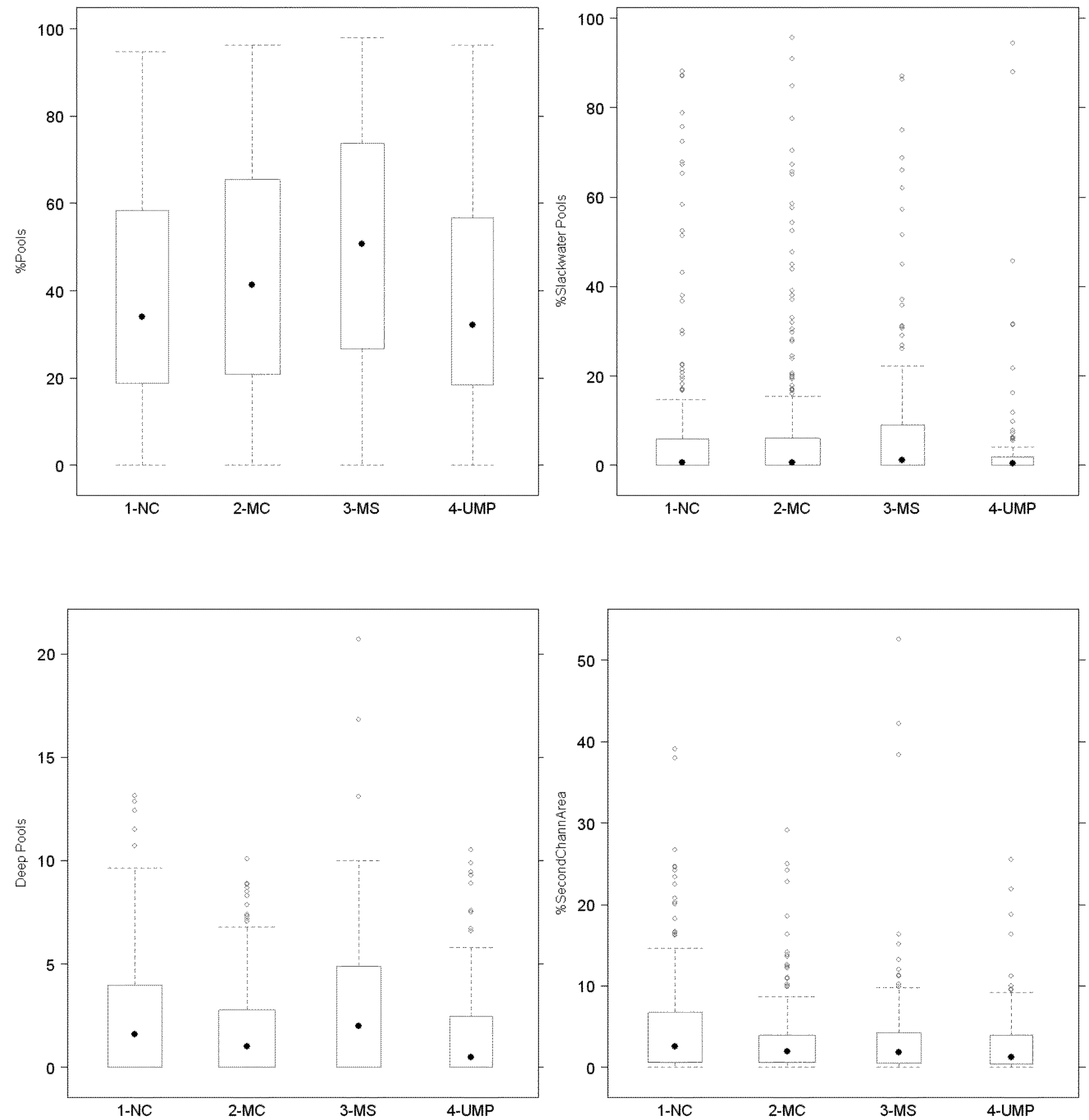


Figure 3. Boxplots of channel morphology variables (percent pools, percent slackwater pools, pools > 1 meter deep, and percent secondary channels) in four monitoring areas in the coast coho ESU.

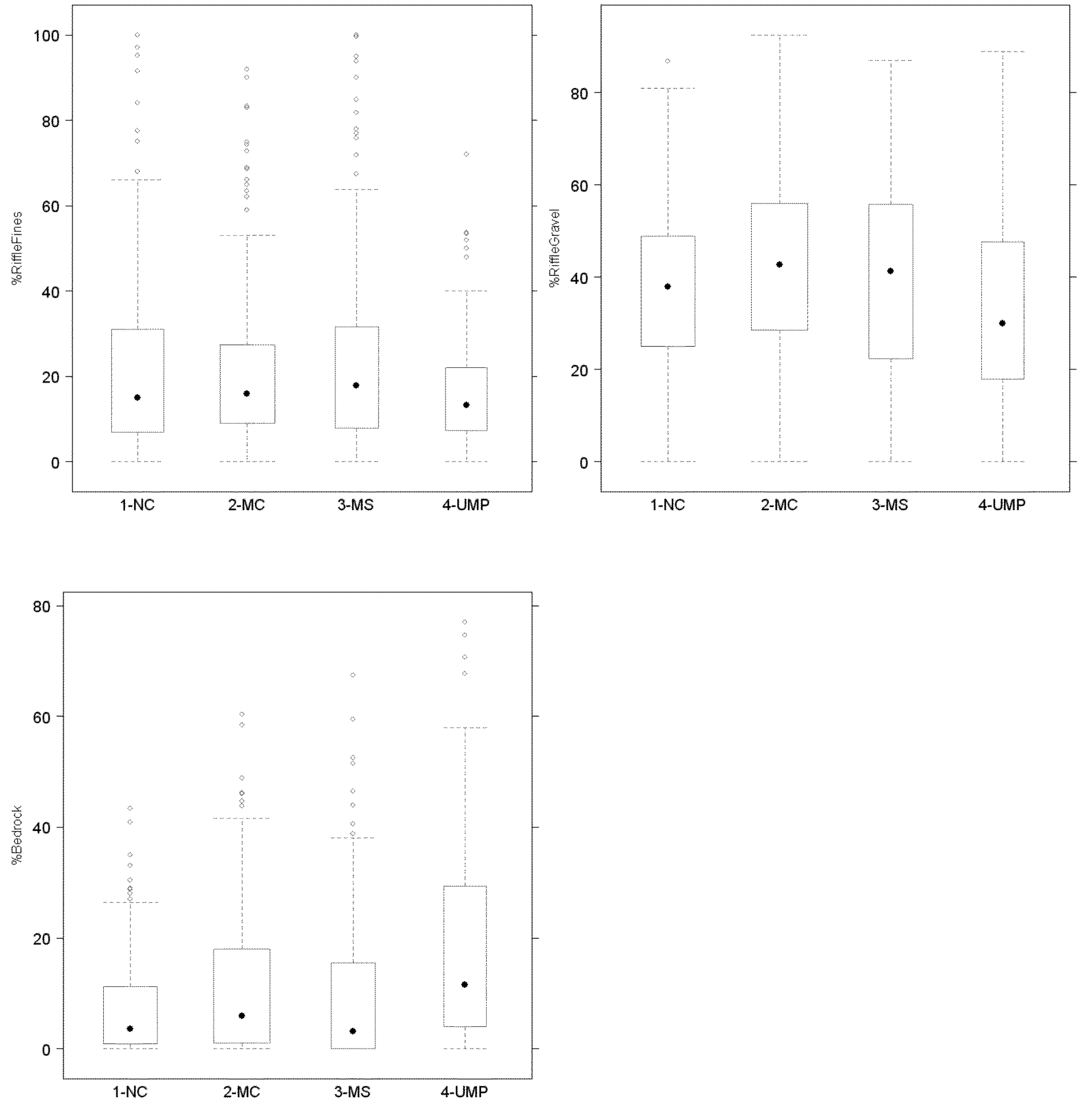


Figure 4. Boxplots of substrate variables (fine sediment, gravel, and bedrock) in four monitoring areas in the coast coho ESU.

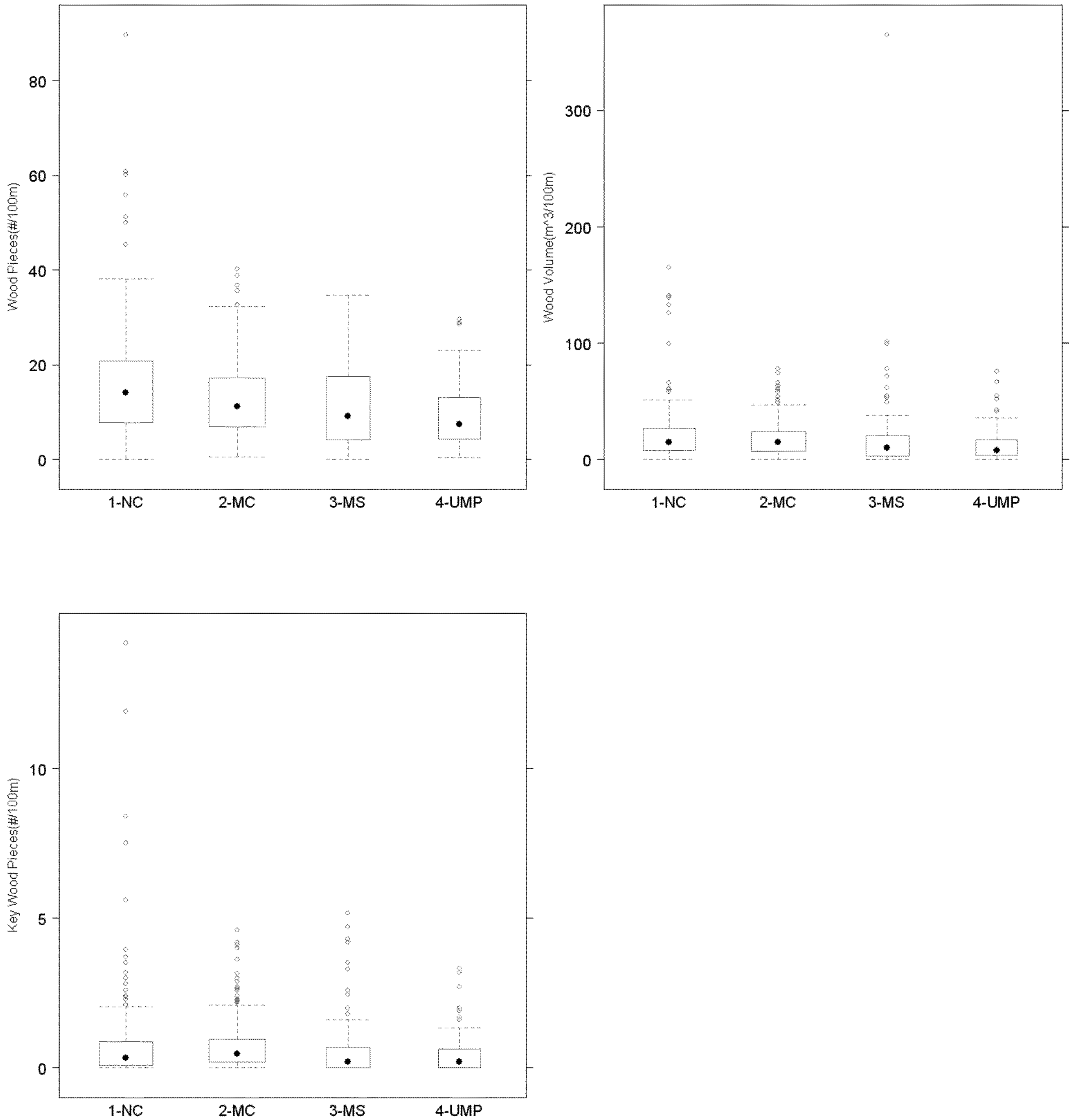


Figure 5. Boxplots of channel roughness variables (wood pieces, wood volume, and key pieces of wood) in four monitoring areas in the coast coho ESU.

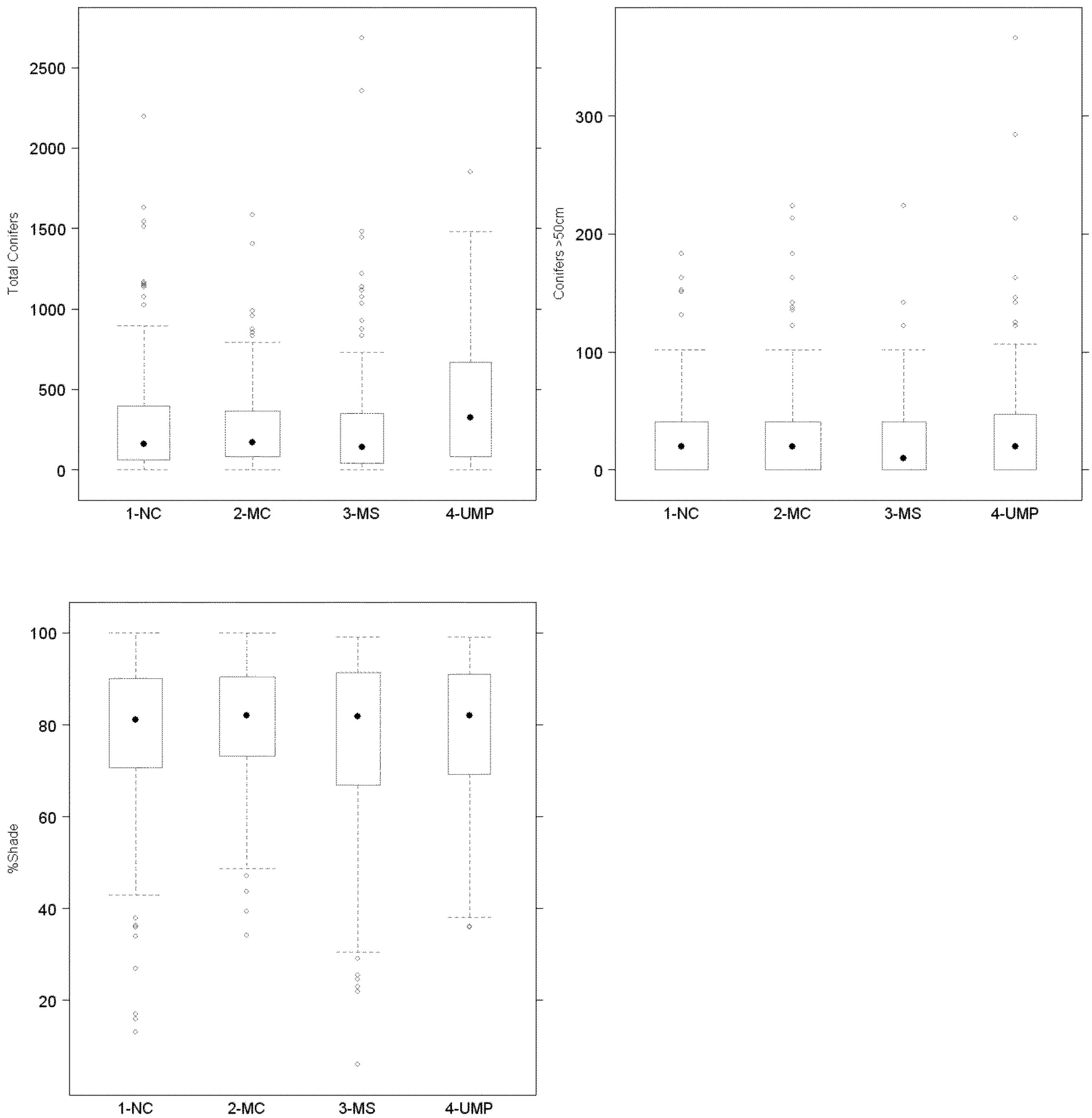


Figure 6. Boxplots of riparian variable (conifers and conifers > 50cm dbh per 1,000 feet of stream, and percent shade) in four monitoring areas in the coast coho ESU.

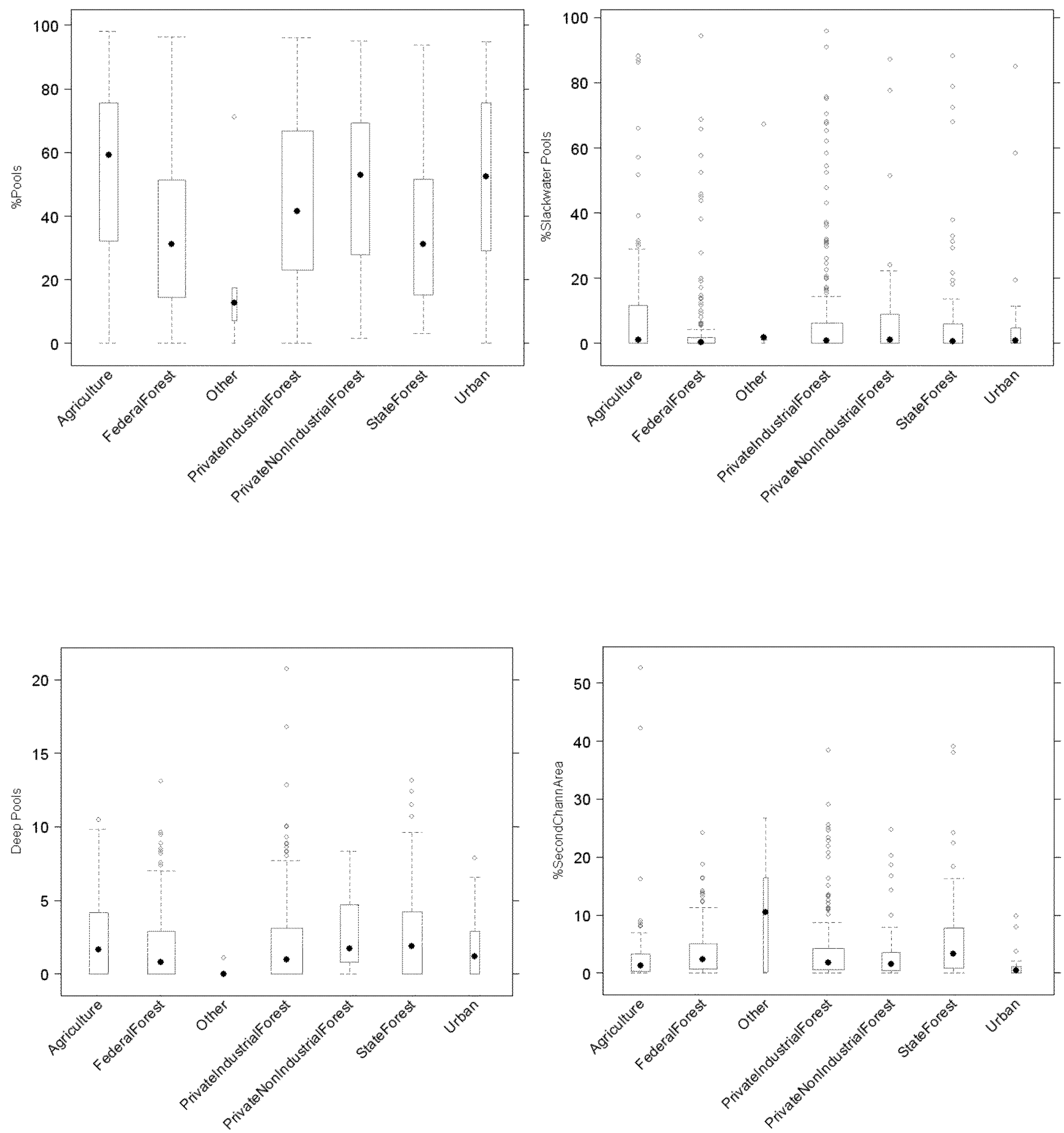


Figure 7. Boxplots of channel morphology variables (percent pools, percent slackwater pools, pools > 1 meter deep, and percent secondary channels) in seven land use categories in the coast coho ESU.

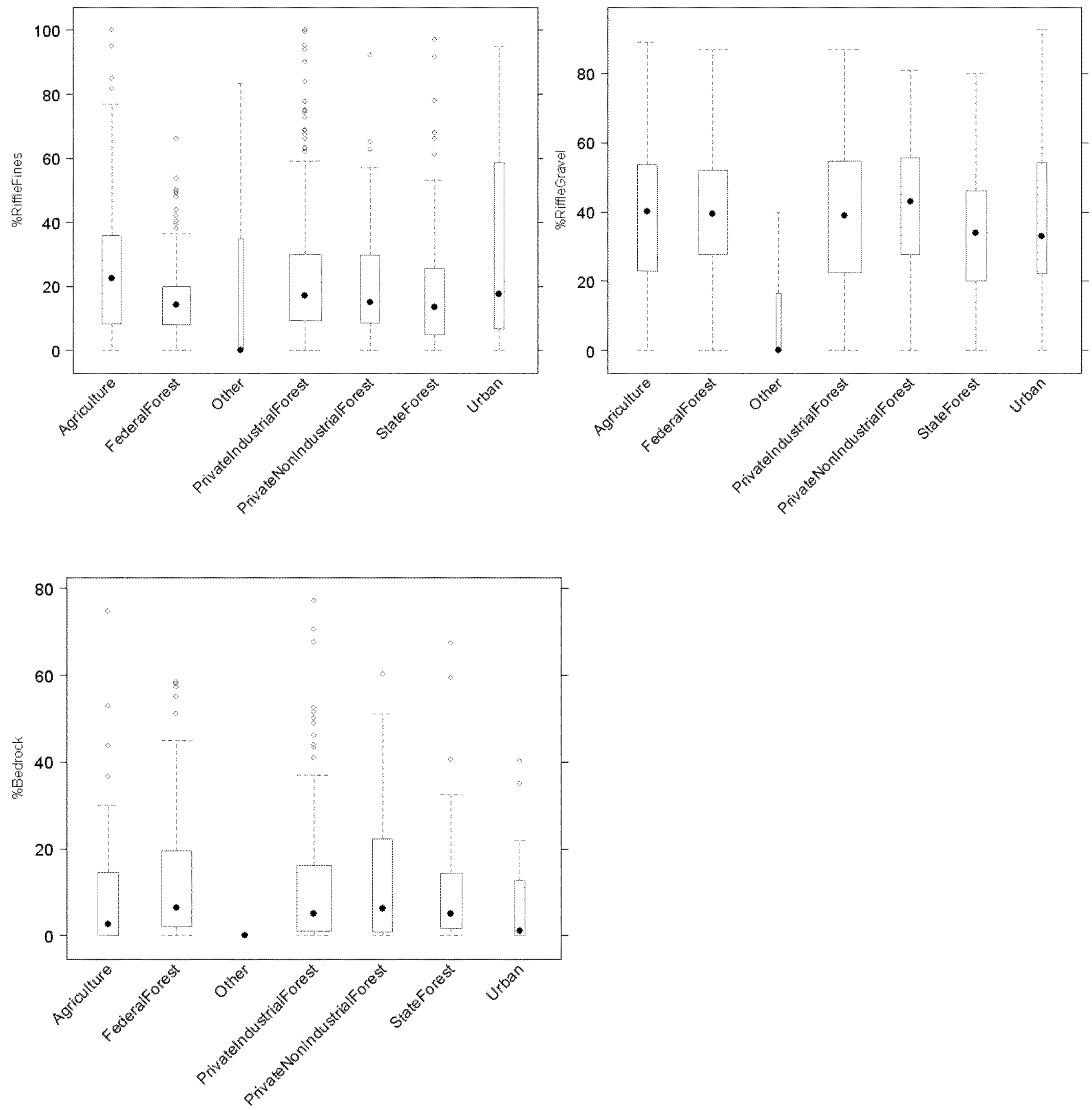


Figure 8. Boxplots of substrate variable (fine sediment, gravel, and bedrock) in 7 land use categories in the coast coho ESU.

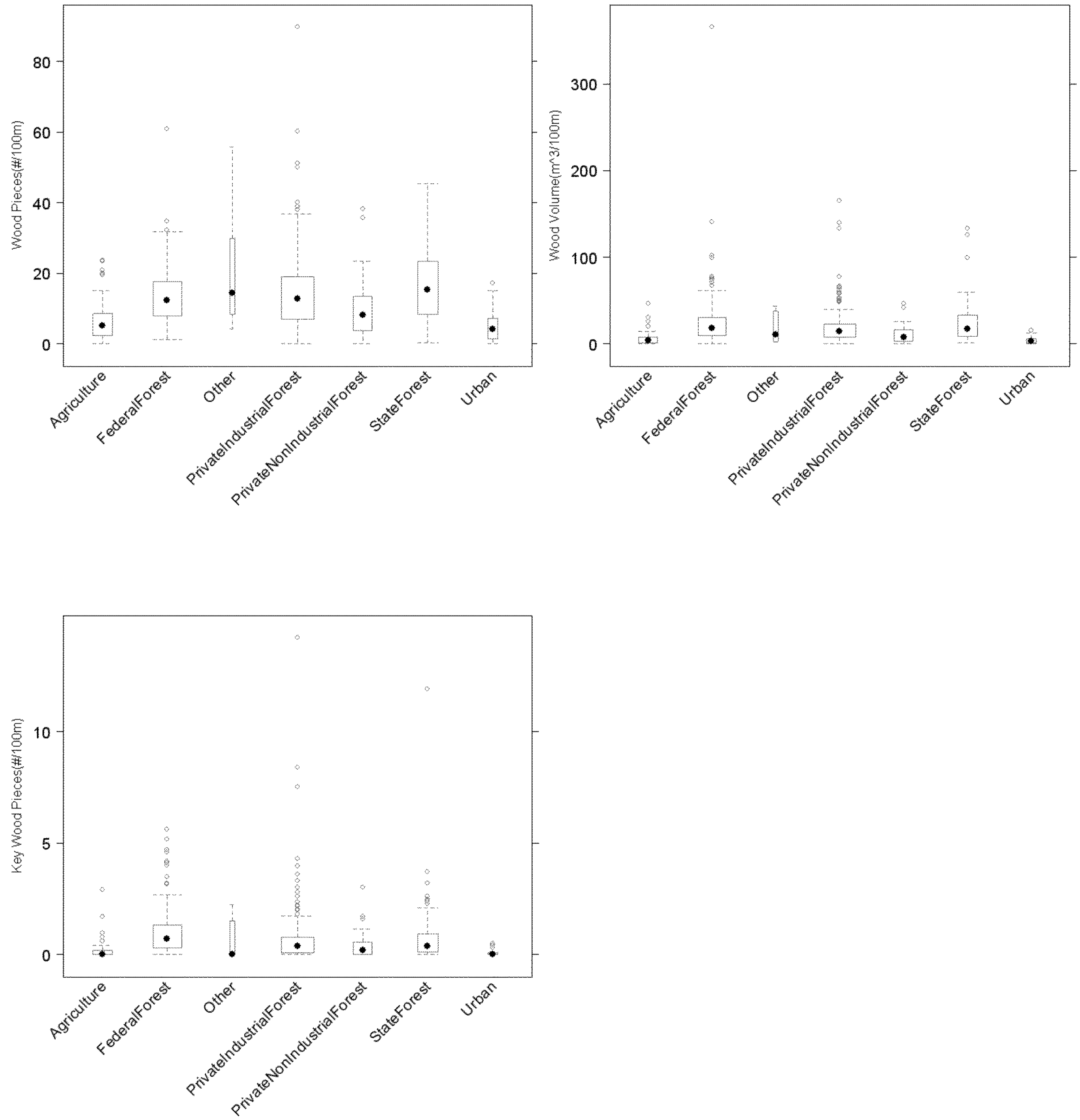


Figure 9. Boxplots of channel roughness variables (wood pieces, wood volume, and key pieces of wood) in seven land use categories in the coast coho ESU.

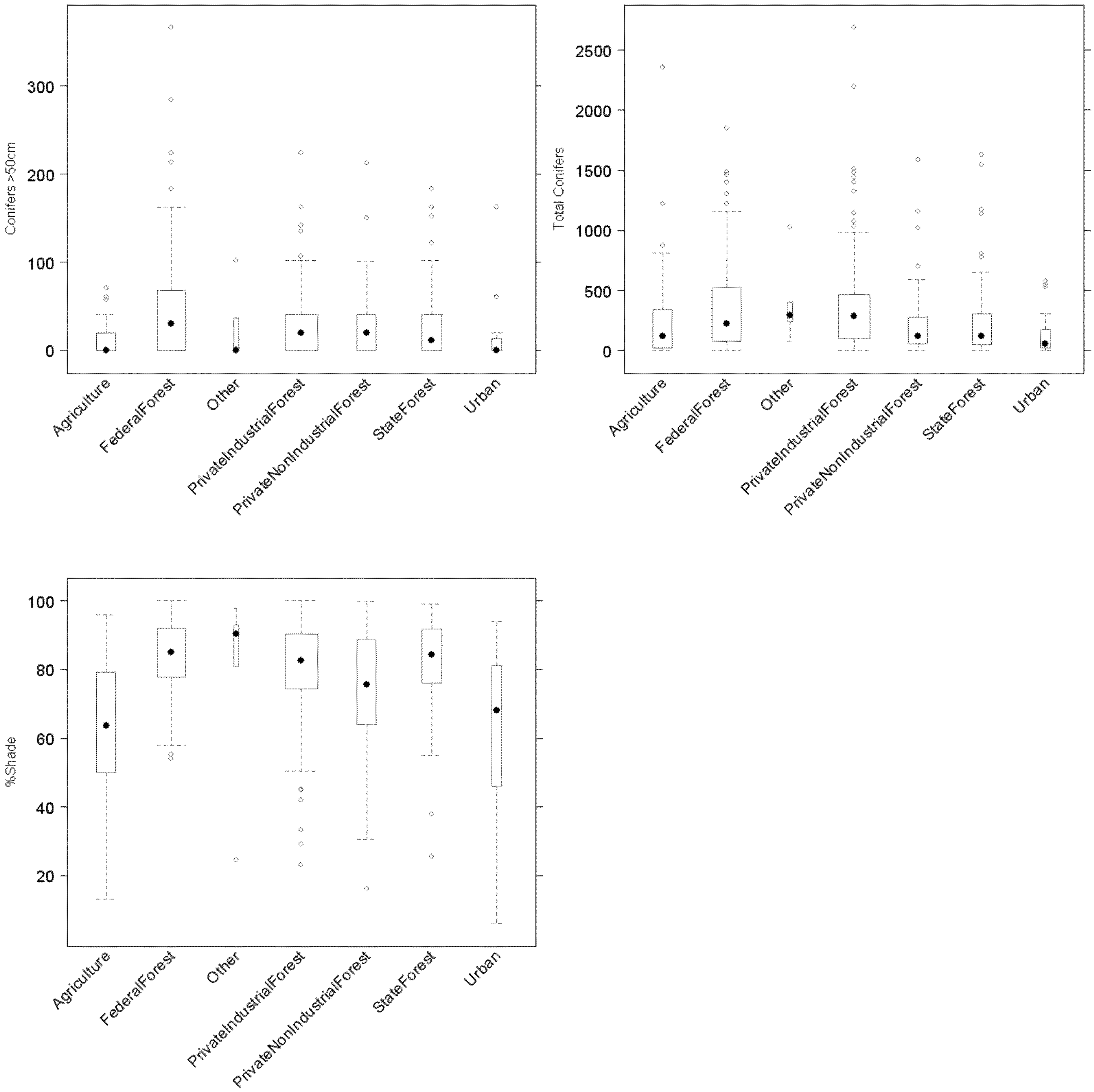
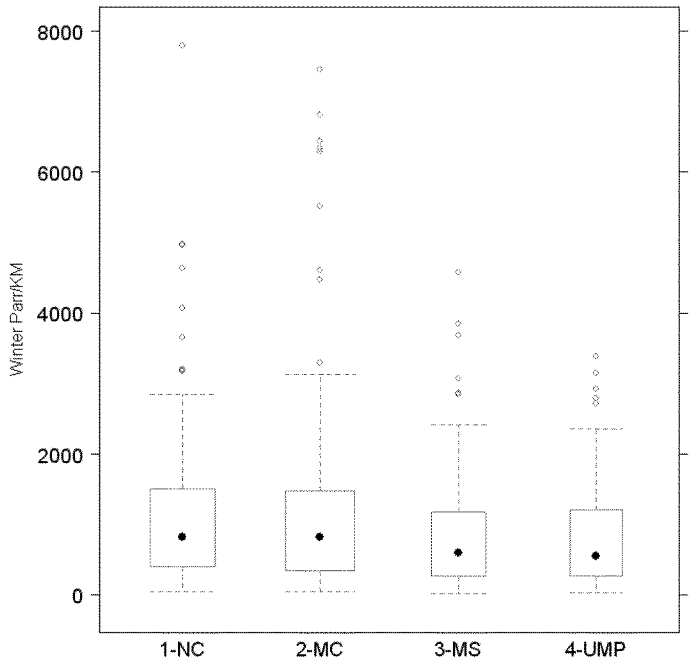


Figure 10. Boxplots of riparian variables (conifers and conifers > 50cm dbh per 1,000 feet of stream, and percent shade) in seven land use categorie in the coast coho ESU.



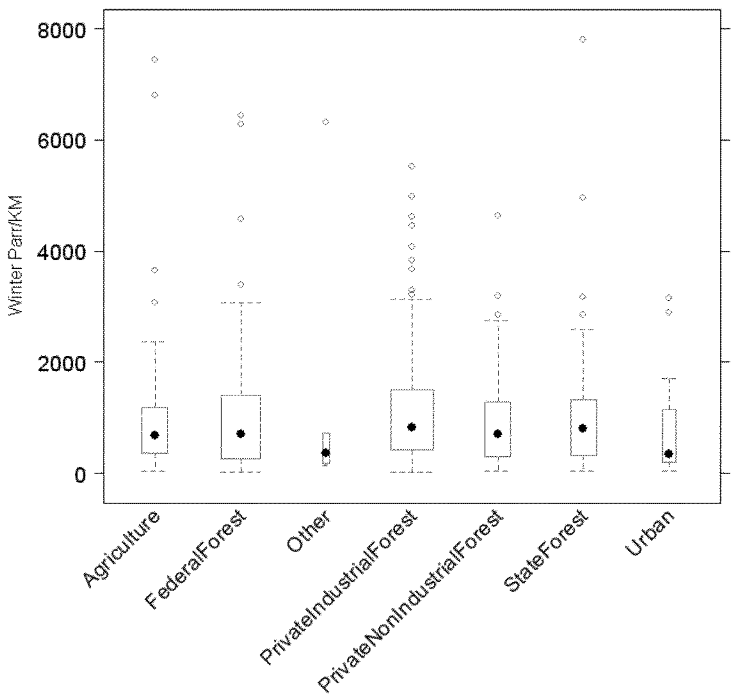


Figure 11. Boxplots of winter rearing capacity for juvenile coho in four monitoring areas (top) and in seven land use categories (bottom) in the coast coho ESU.

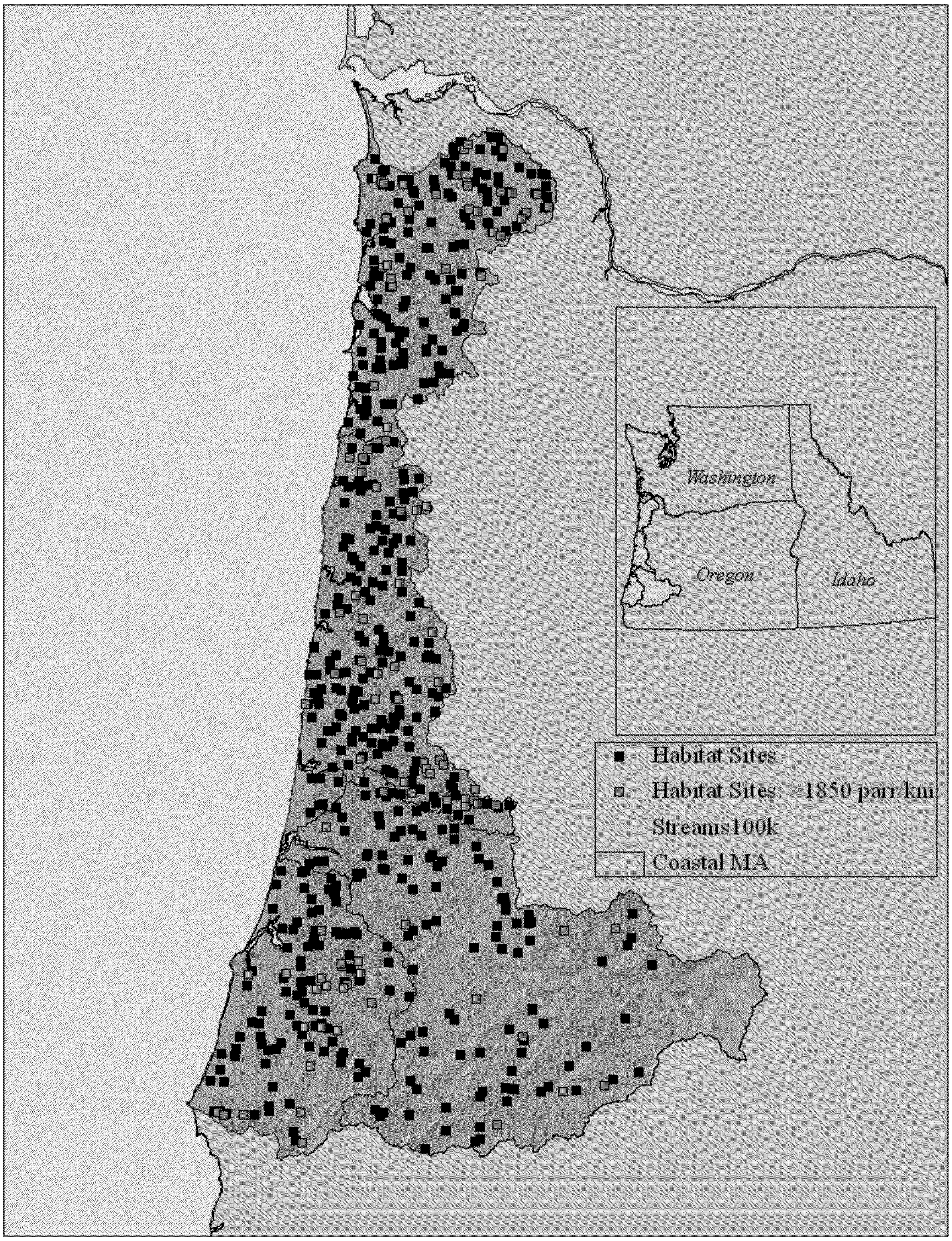


Figure 12. Location of high quality sites that have a winter rearing capacity greater than 1850 parr per kilometer.

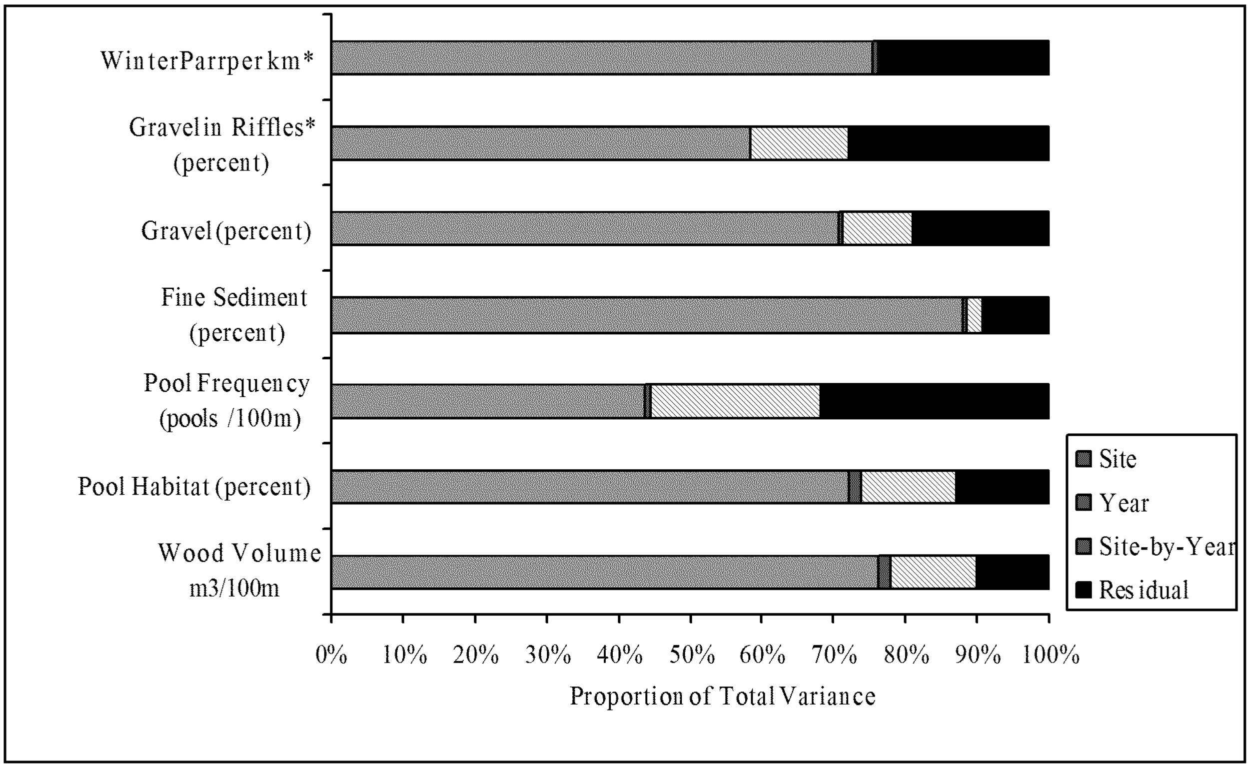


Figure 13. The proportions of variance, relative to the total variance, attributed to each of the four variance components for each of the habitat attributes.

*Year (Gravel in Riffles) and Site*Year (Winter Parr) not estimated by model

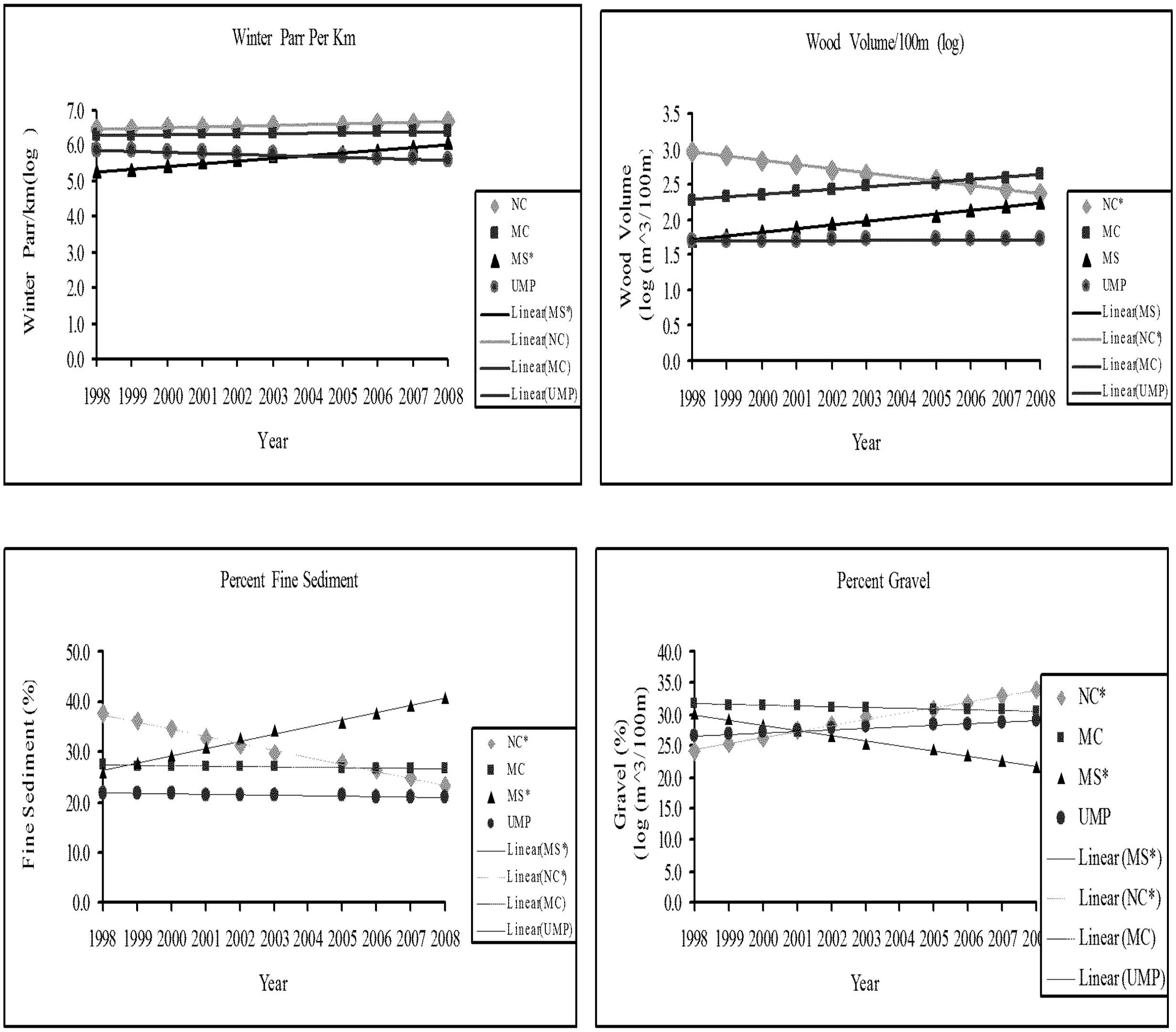


Figure 14. Graphical displays of slope equation representing significant linear trends by year for four of the habitat attributes that had significant (alpha = 0.05) slope estimates.

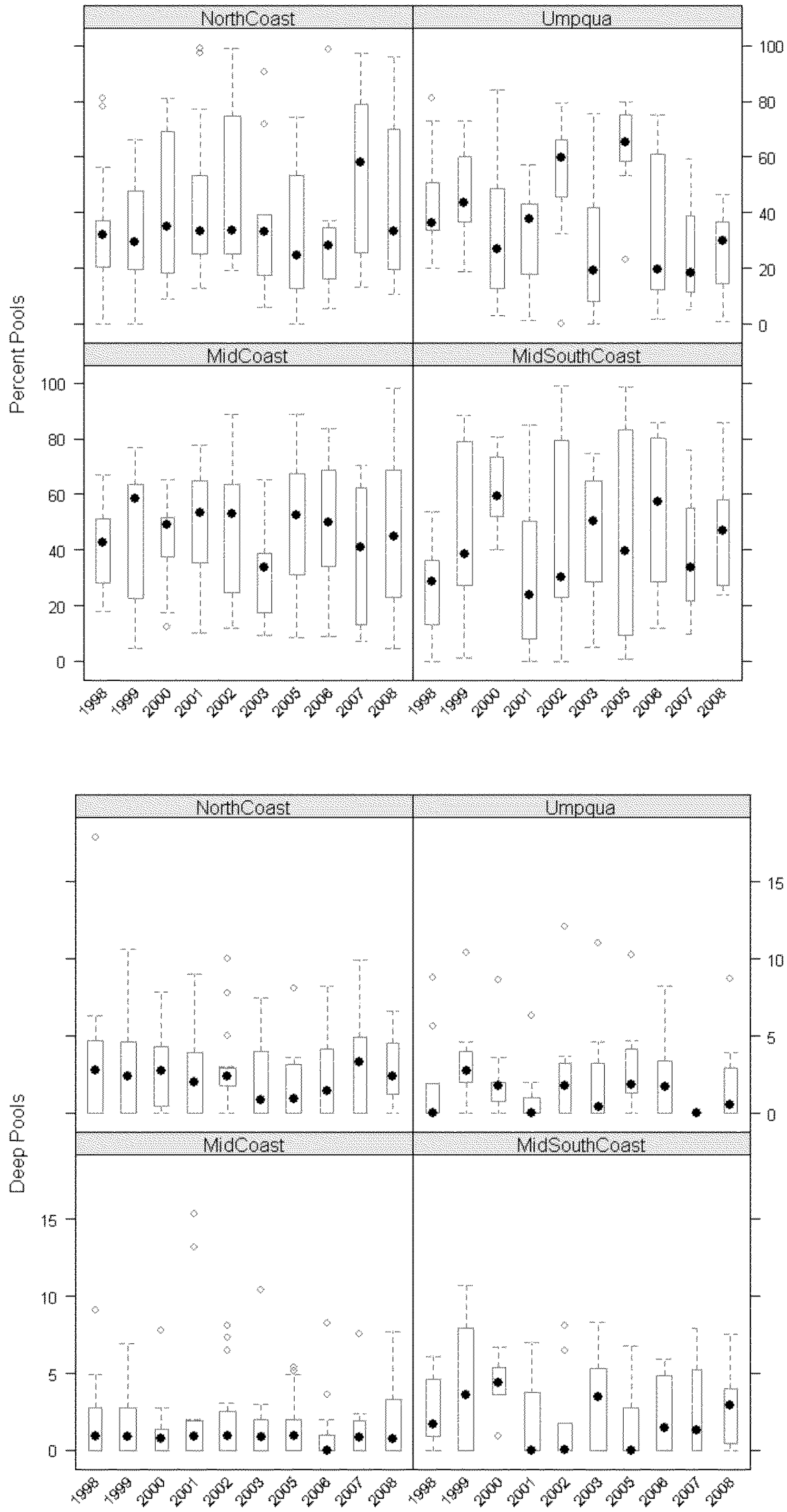


Figure 15. Boxplots of percent pools and pools deeper than 1 meter from 1998 – 2008.

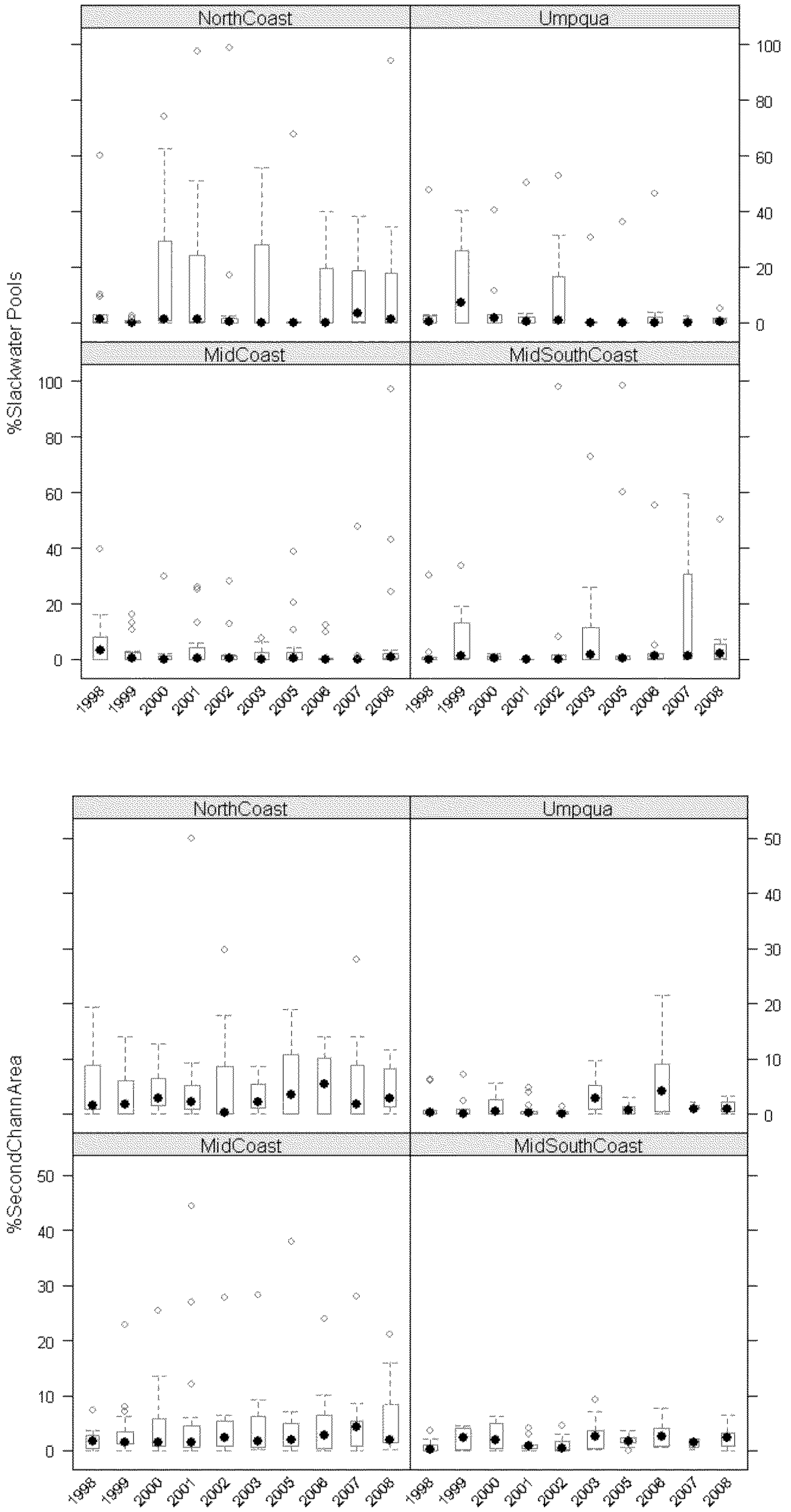
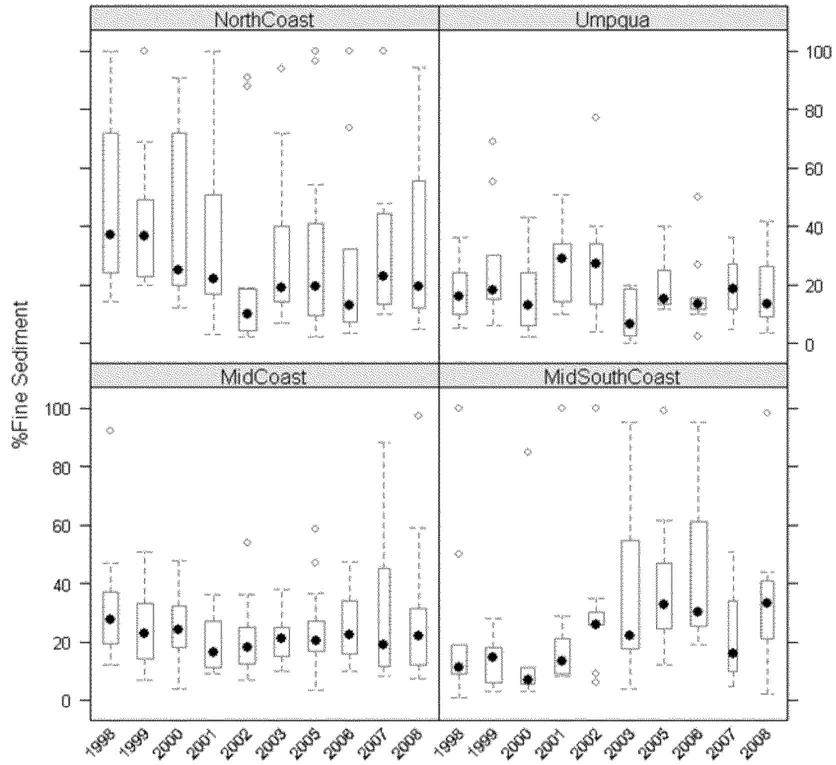


Figure 16. Boxplots of percent slack water pools and secondary channels from 1998 – 2008.



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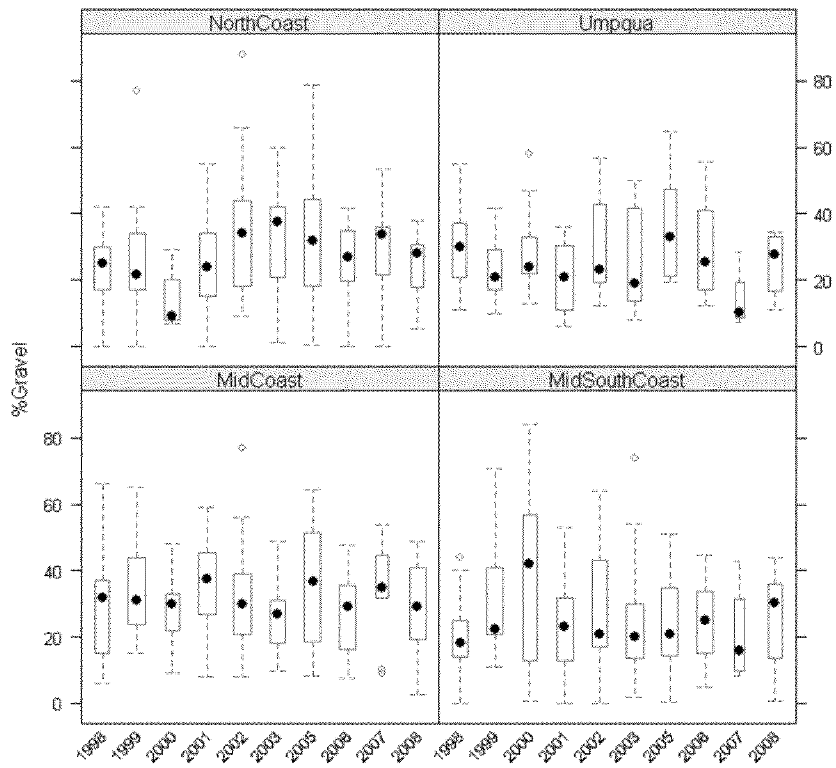

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Figure 17. Boxplots of fine substrate and gravel in streams from 1998 – 2008.

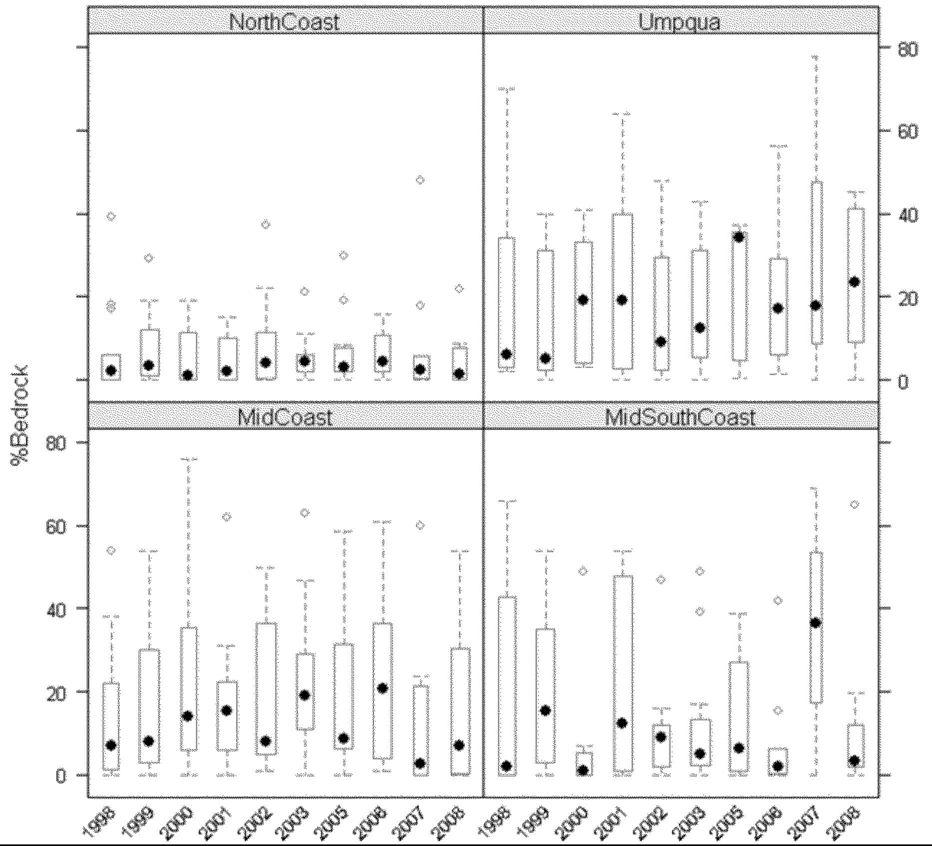

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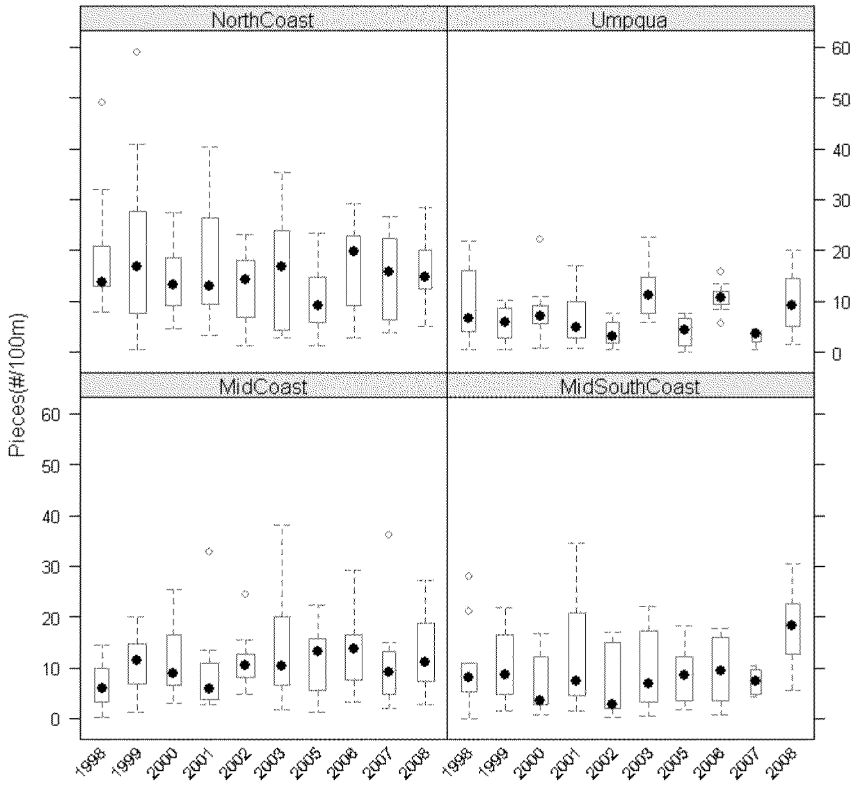
Figure 18. Boxplots of percent bedrock in streams from 1998 – 2008.



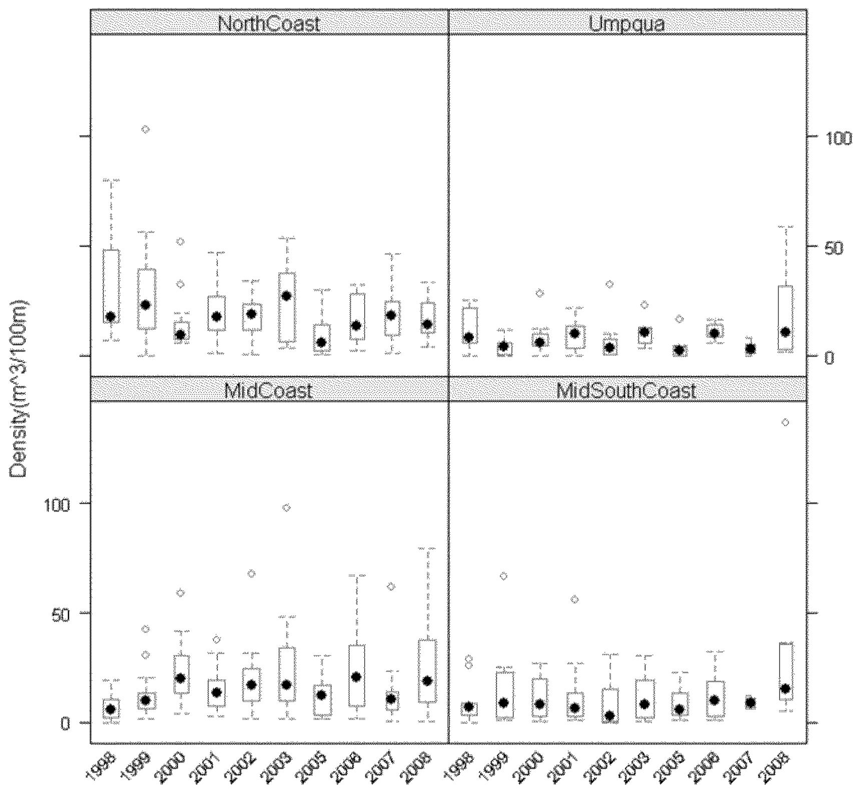


Figure 19. Boxplots of large wood pieces and volume from 1998 – 2008.

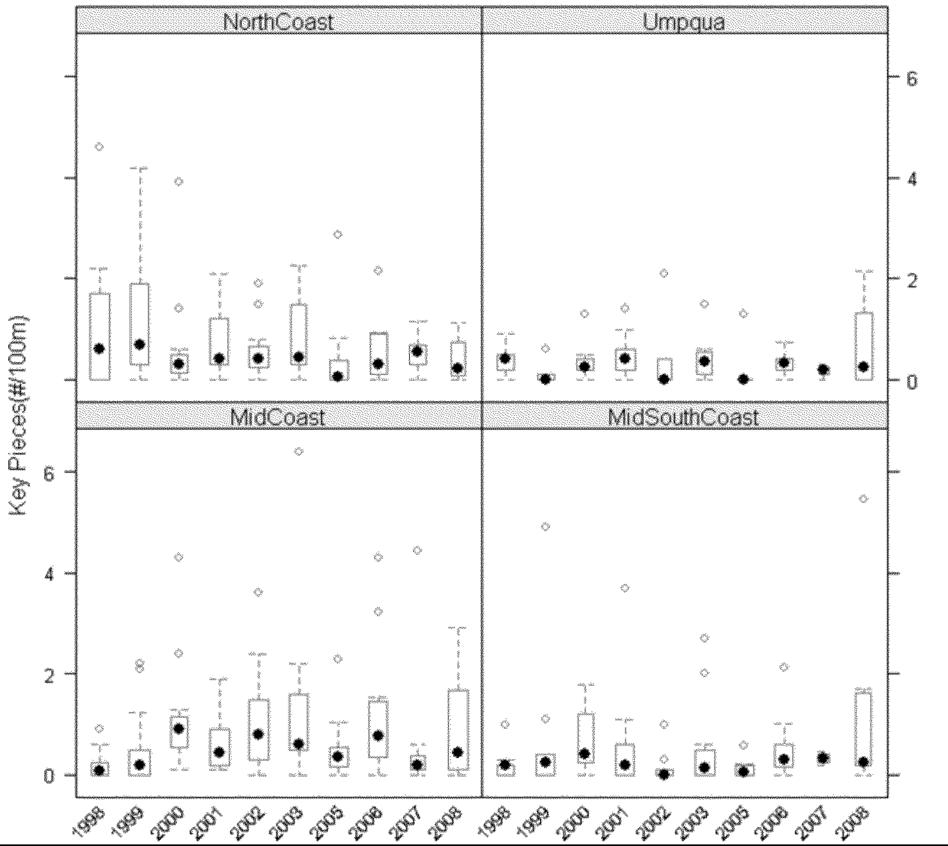


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Figure 20. Boxplots of key pieces of wood from 1998 – 2008.

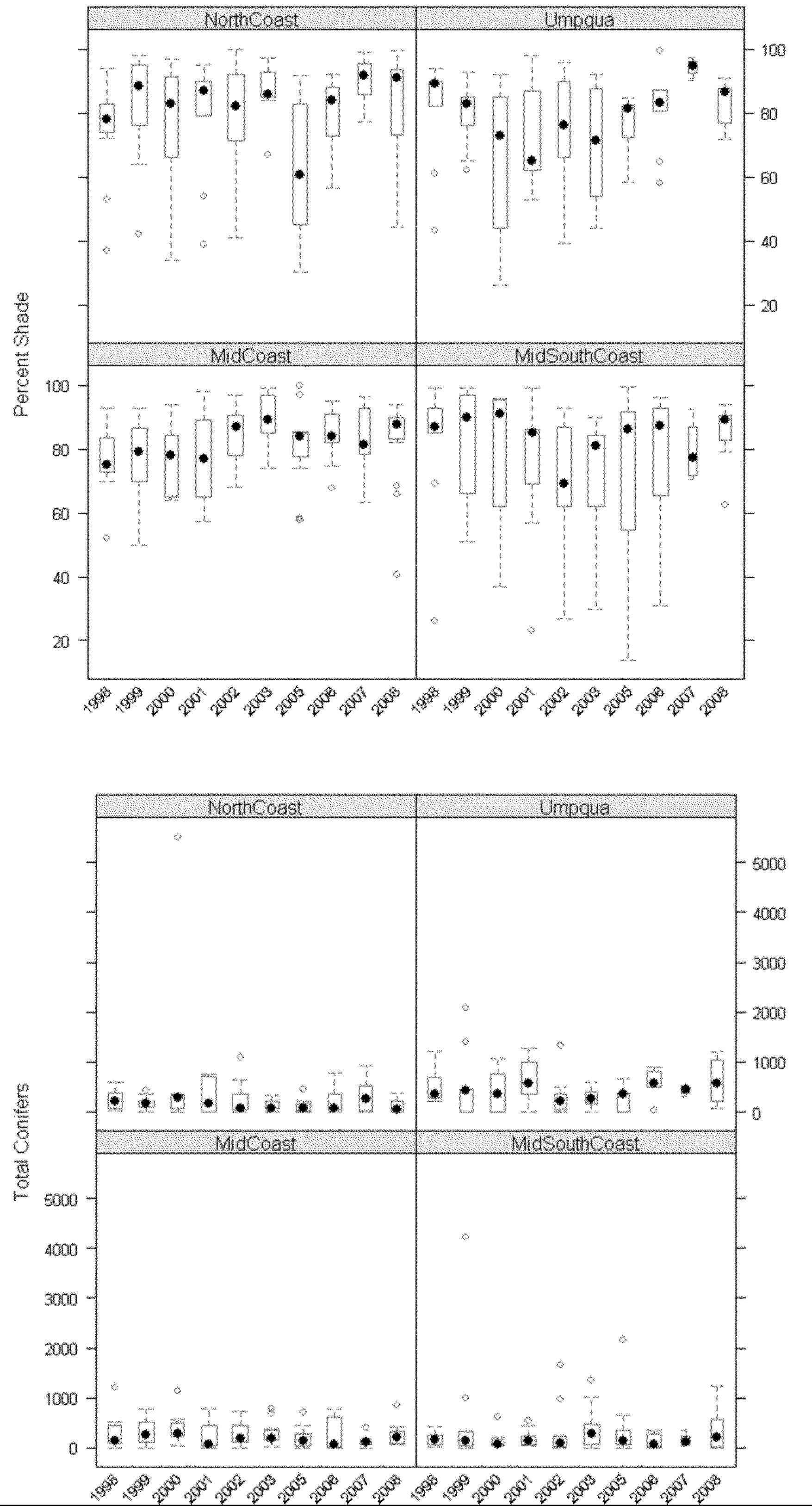

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Figure 21. Boxplots of shade and total conifers per 1,000 feet of stream from 1998 – 2008.

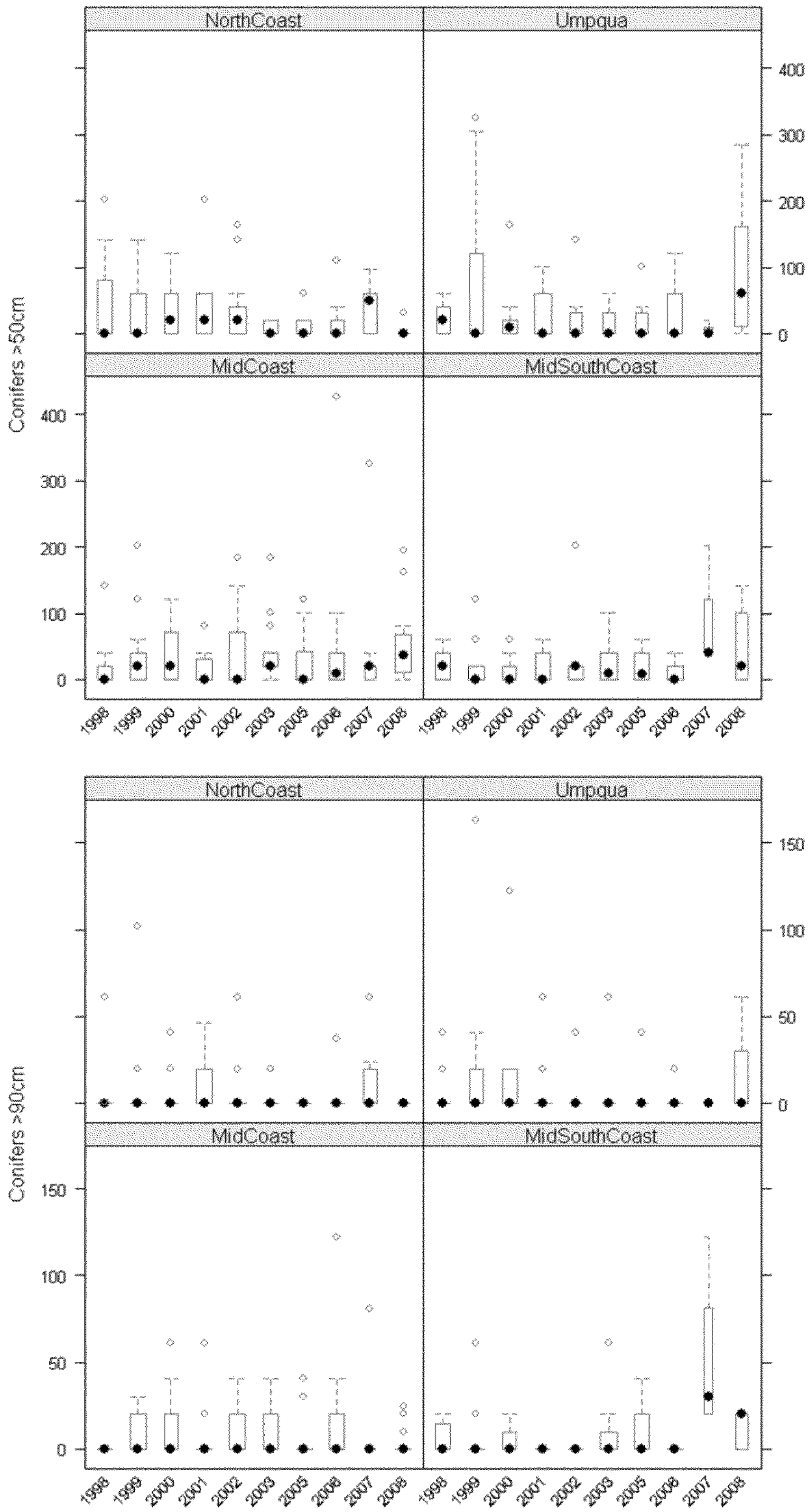

Figure 22. Boxplots of conifers > 50 cm dbh and conifers >90 cm dbh in a 1,000 foot length of stream from 1998 – 2008.

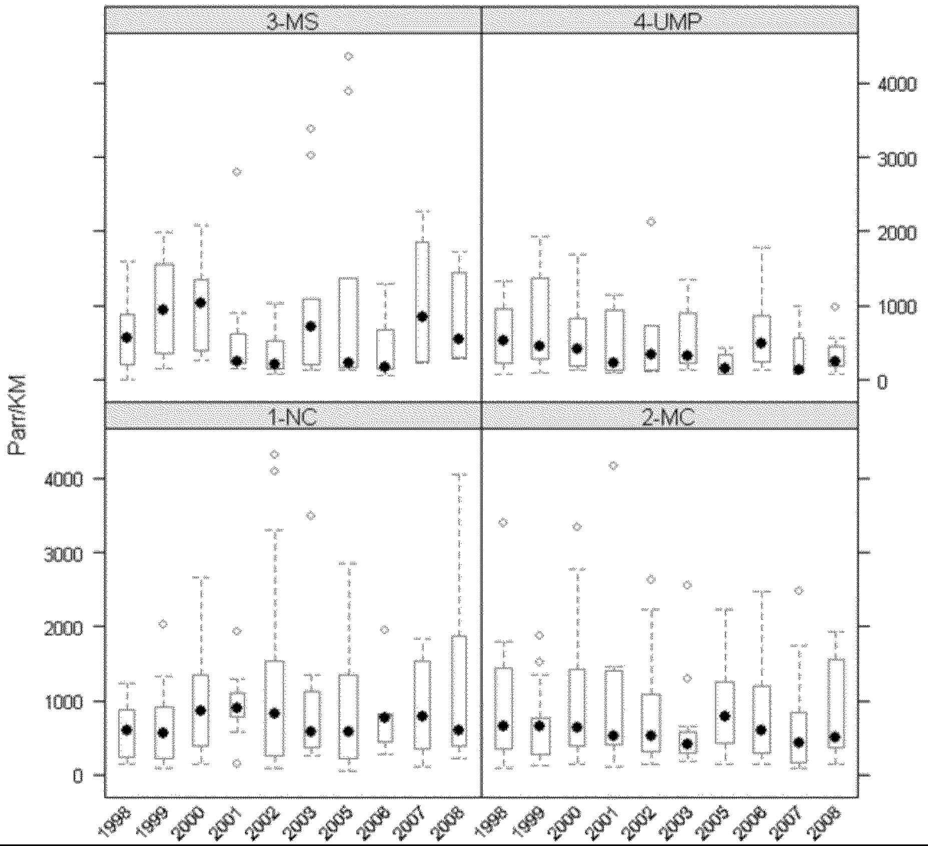

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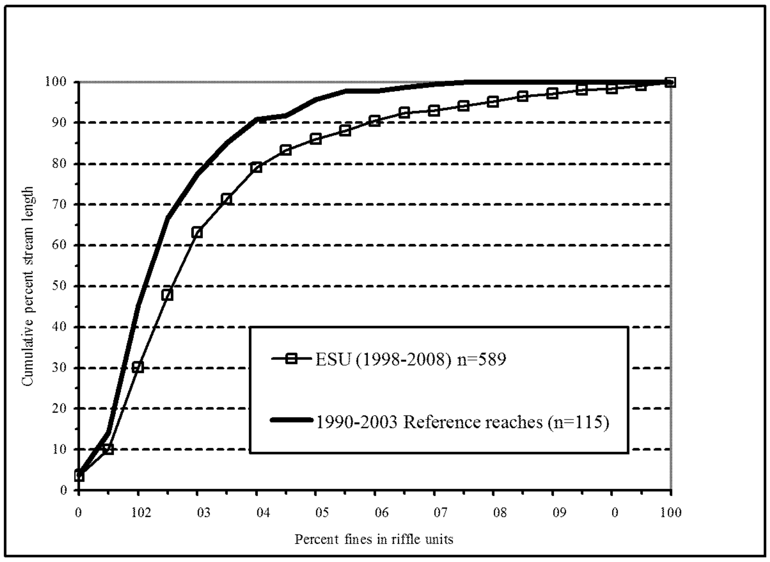
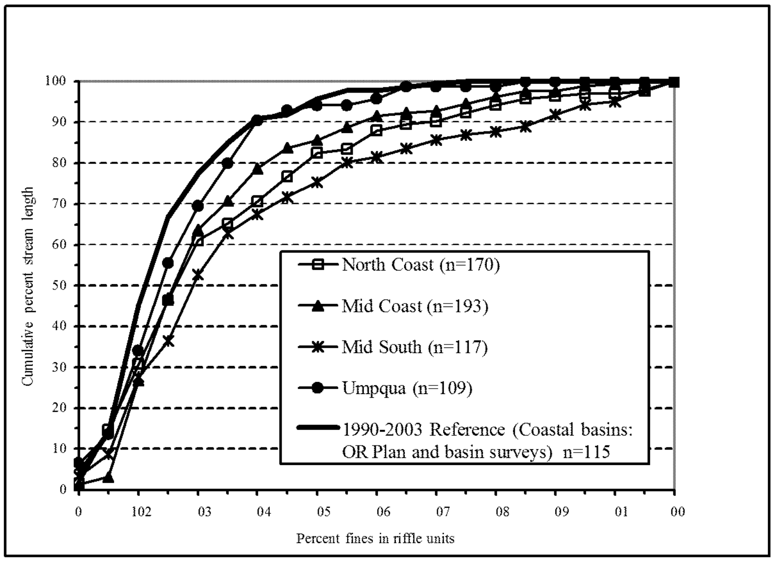
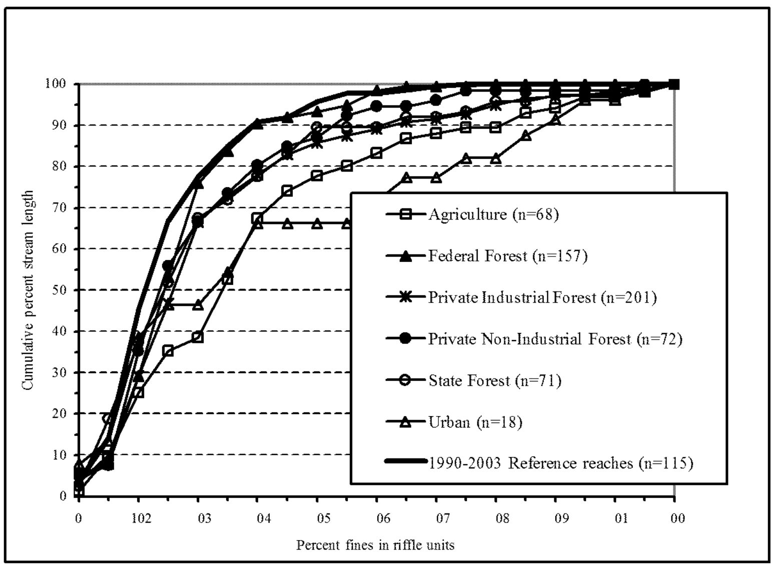
Figure 23. Boxplot of winter rearing capacity for juvenile coho from 1998 – 2008.

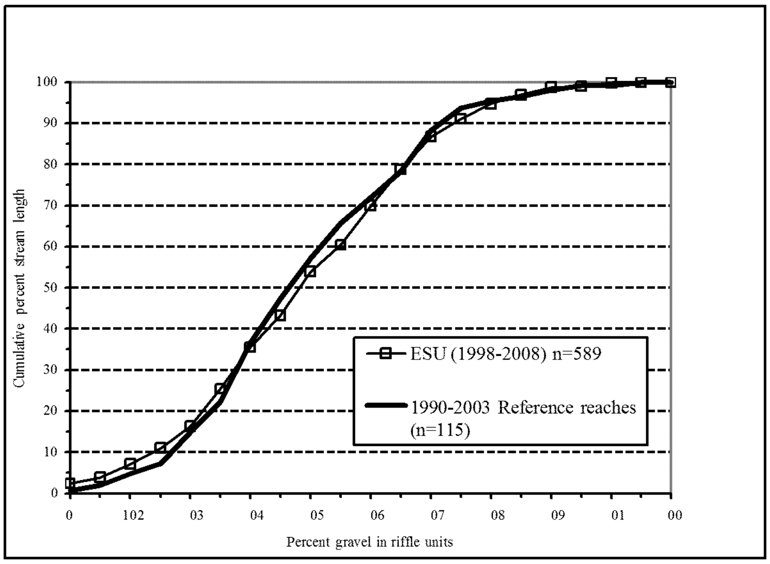
APPENDIX A

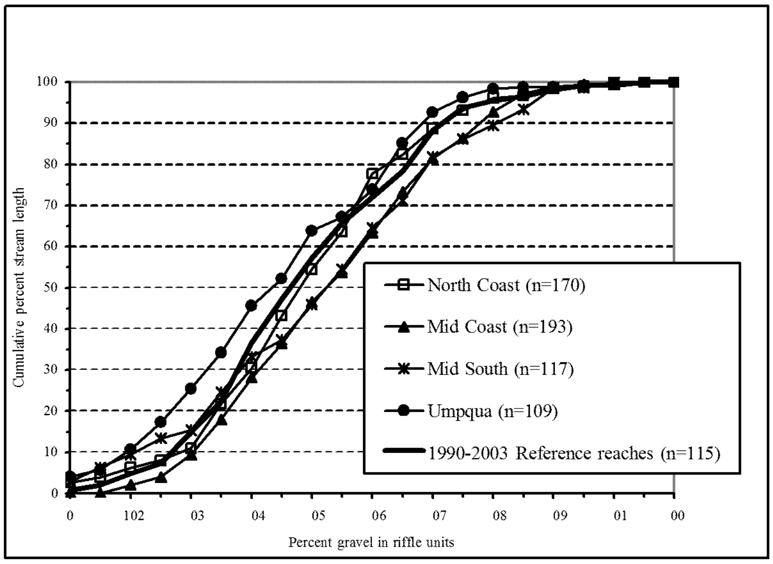


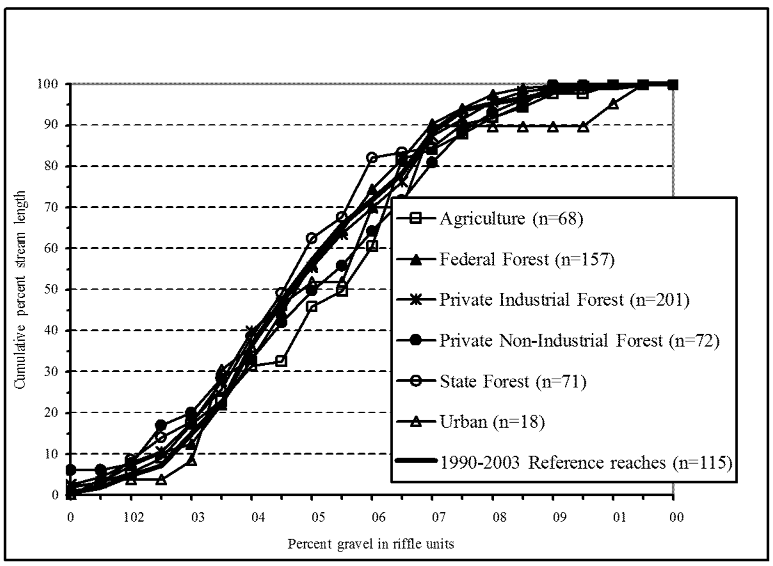




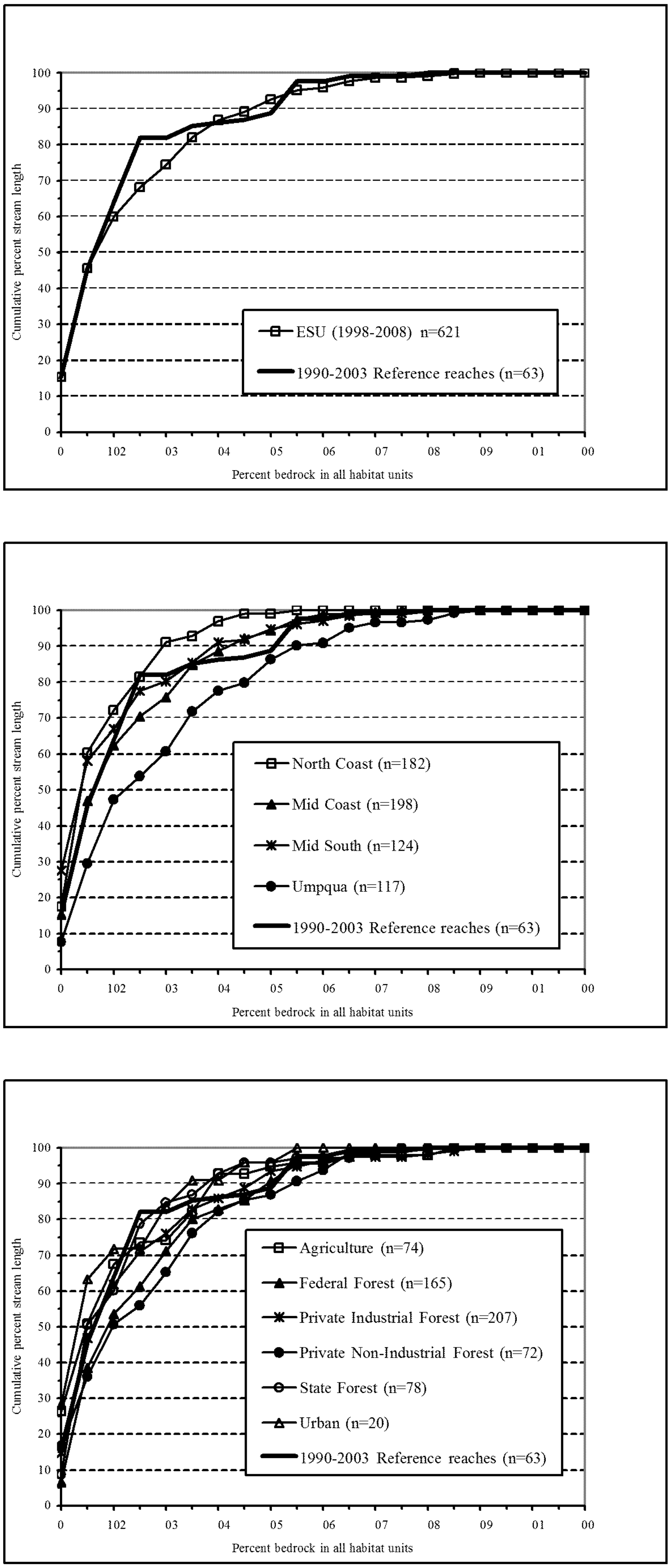
Appendix Figure A-1. Cumulative frequency distribution comparing fines in riffles to reference conditions within coastal ESU, strata, and land use.



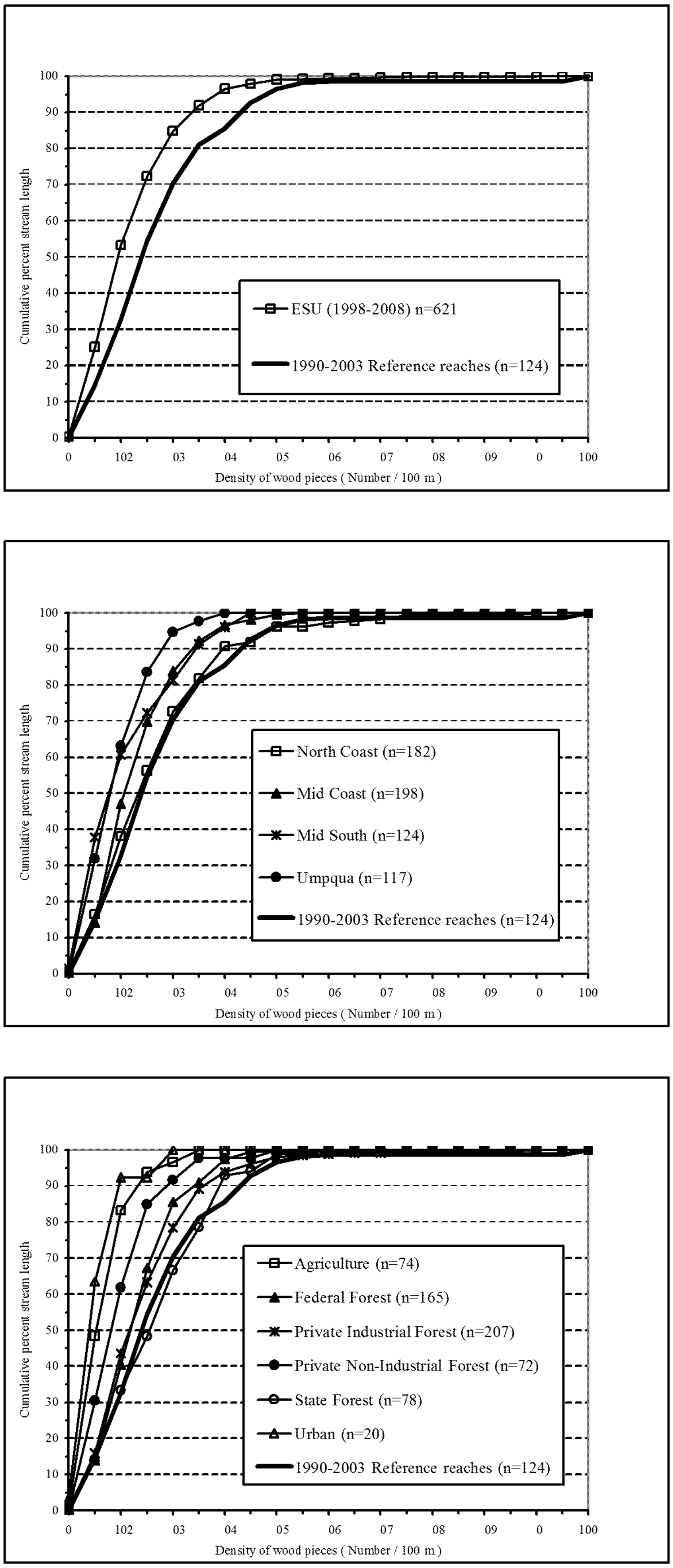




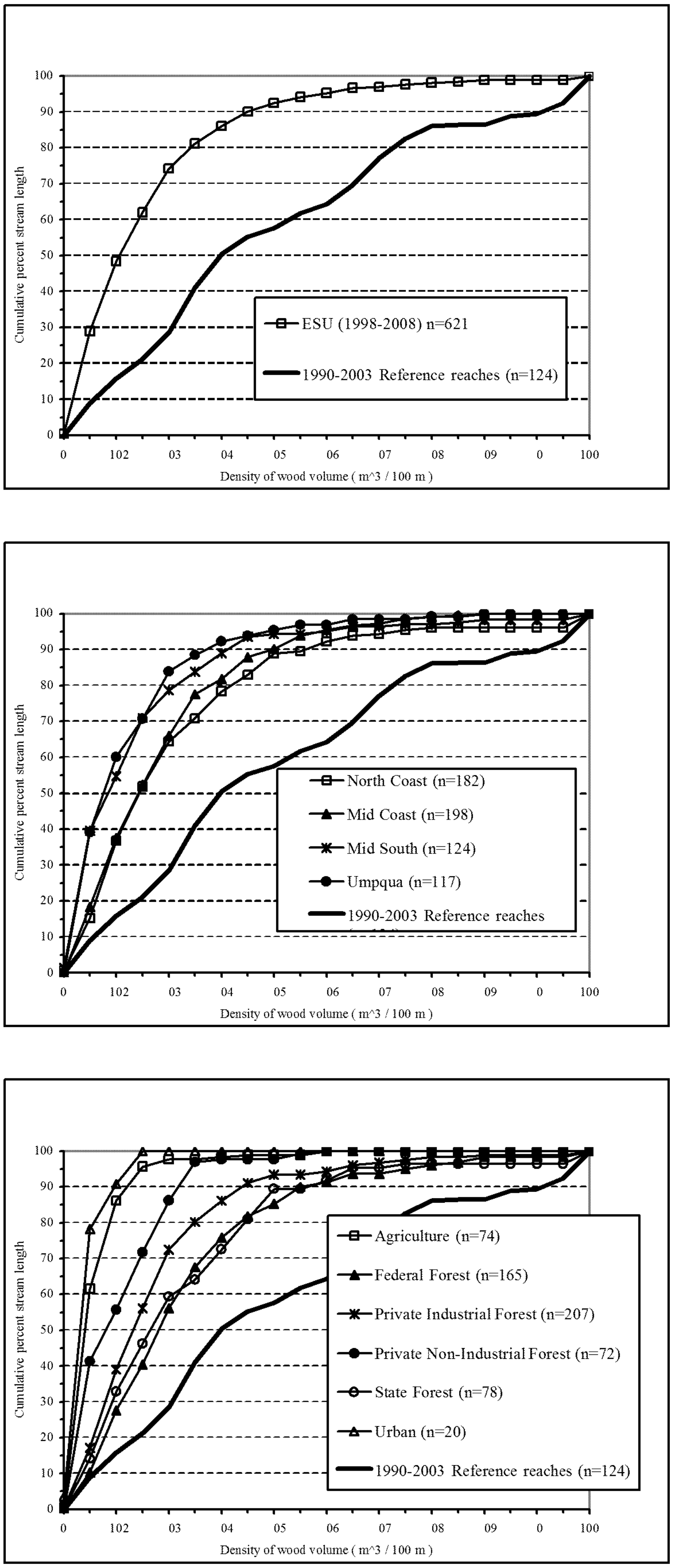
Appendix Figure A-2. Cumulative frequency distribution comparing gravels in riffles to reference conditions within coastal ESU, strata, and land use.



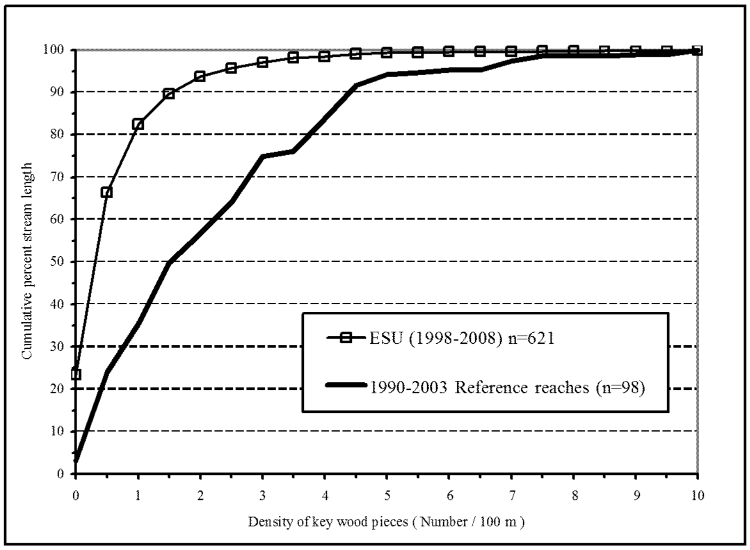
Appendix Figure A-3. Cumulative frequency distribution comparing bedrock to reference conditions within coastal ESU, strata, and land use.

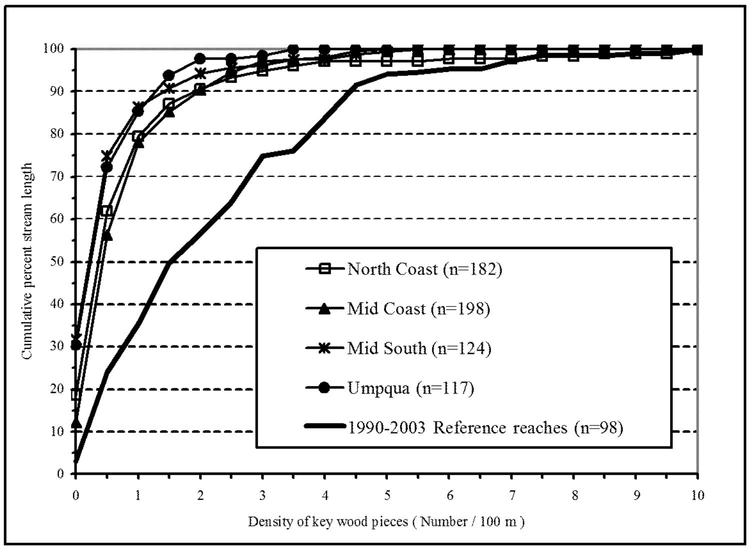


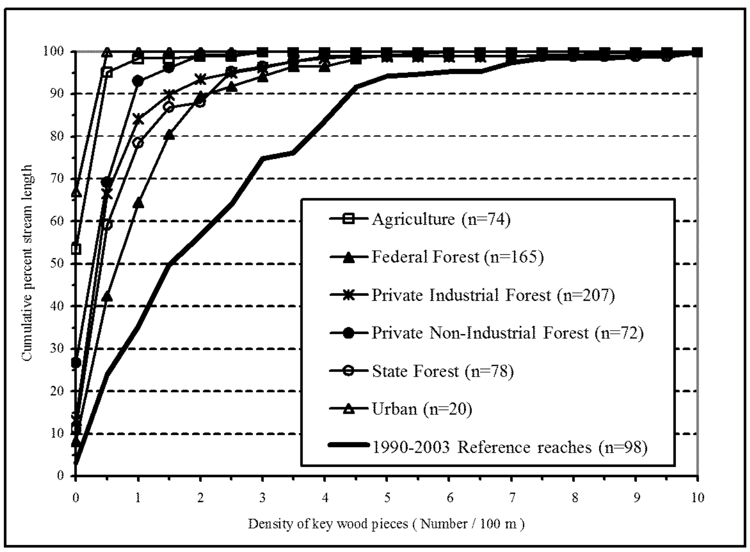
Appendix Figure A-4. Cumulative frequency distribution comparing LWD pieces to reference conditions within coastal ESU, strata, and land use.



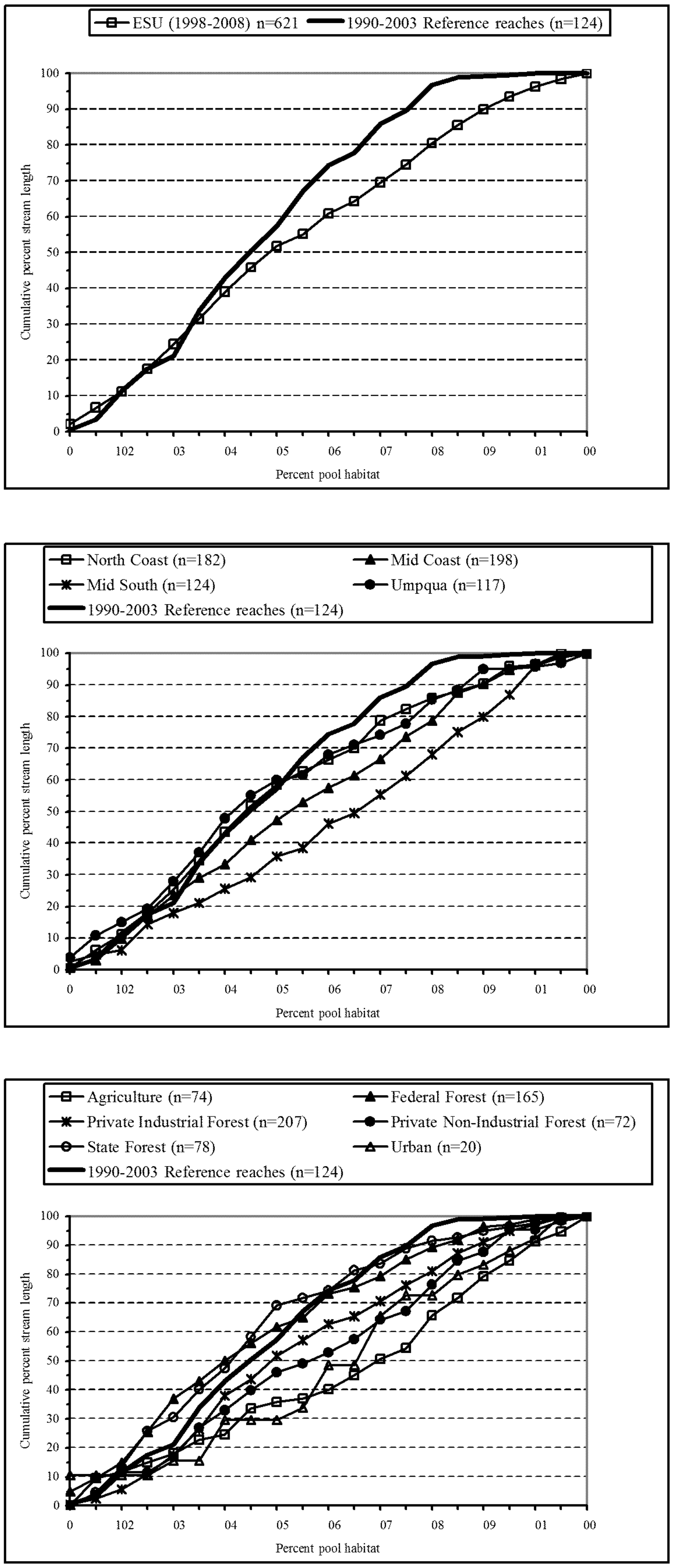
Appendix Figure A-5. Cumulative frequency distribution comparing LWD volume to reference conditions within coastal ESU, strata, and land use.



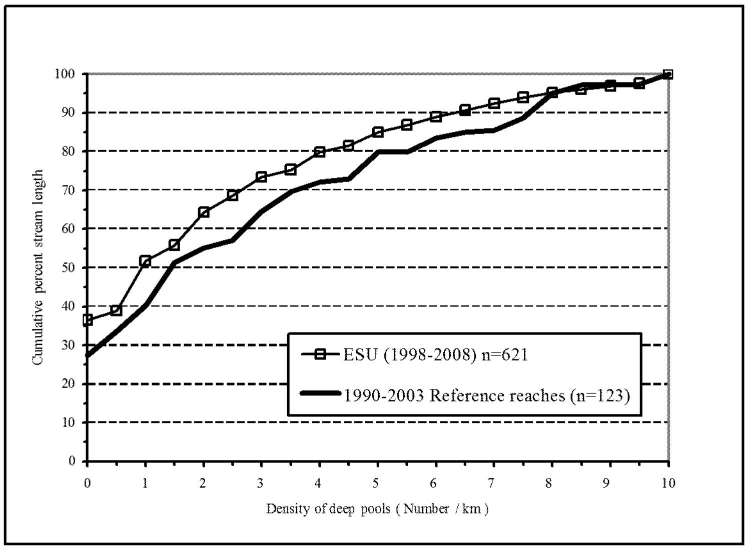


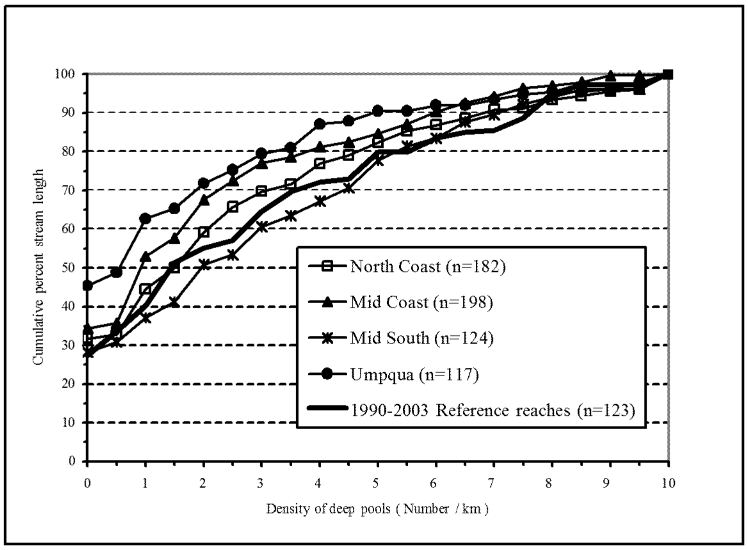


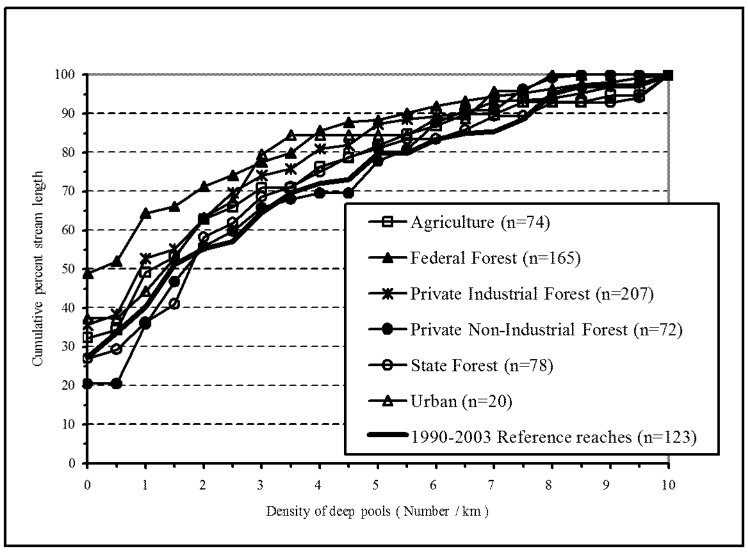
Appendix Figure A-6. Cumulative frequency distribution comparing LWD key pieces to reference conditions within coastal ESU, strata, and land use.



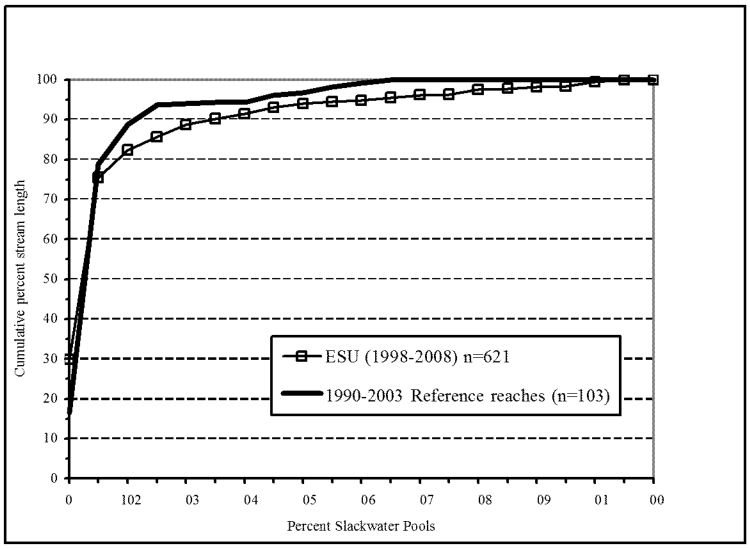
Appendix Figure A-7. Cumulative frequency distribution comparing pool habitat to reference conditions within coastal ESU, strata, and land use.

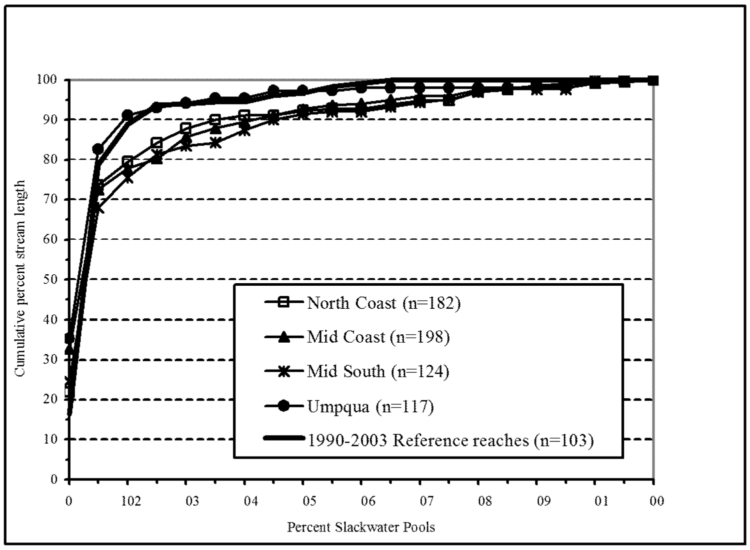


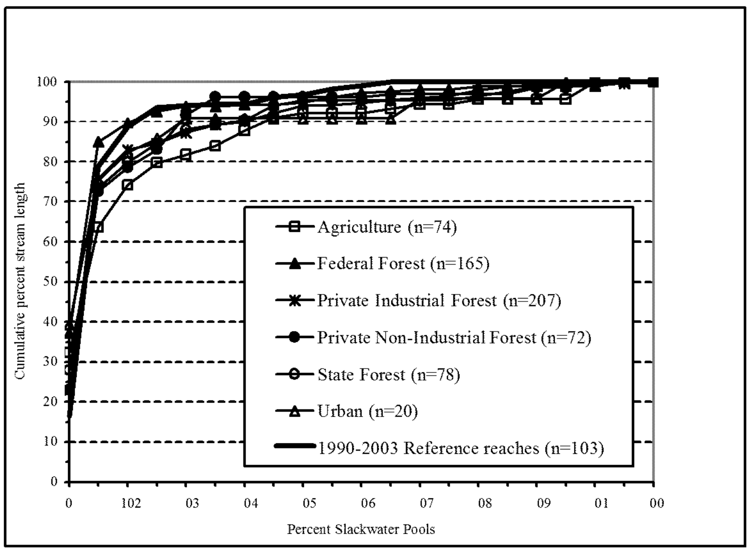




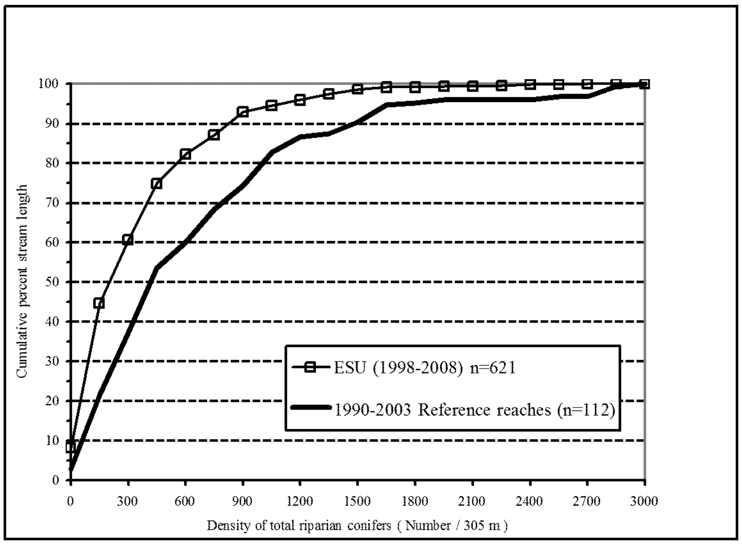
Appendix Figure A-8. Cumulative frequency distribution comparing deep pool habitat to reference conditions within coastal ESU, strata, and land use.

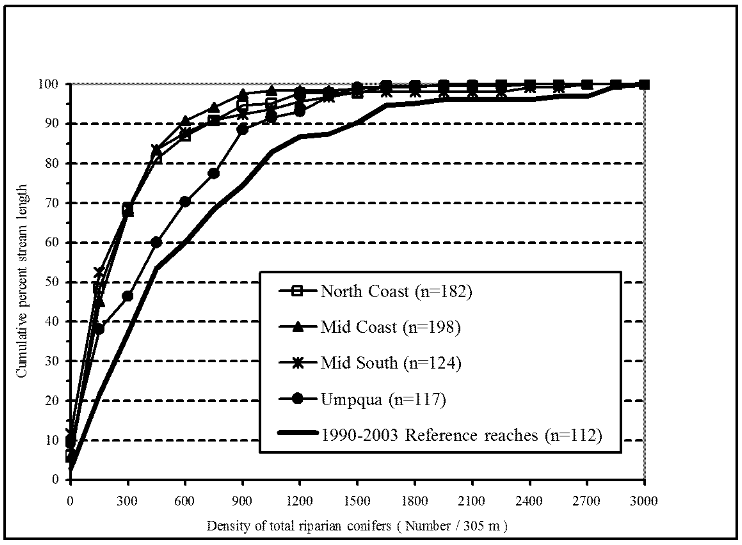


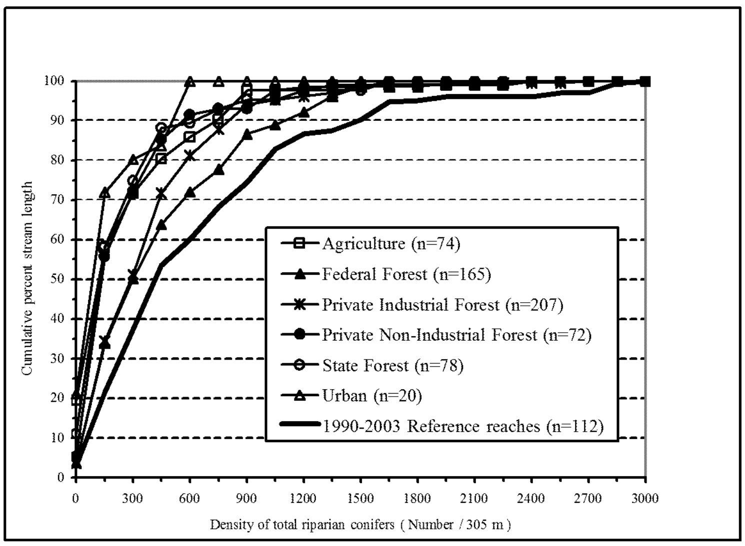




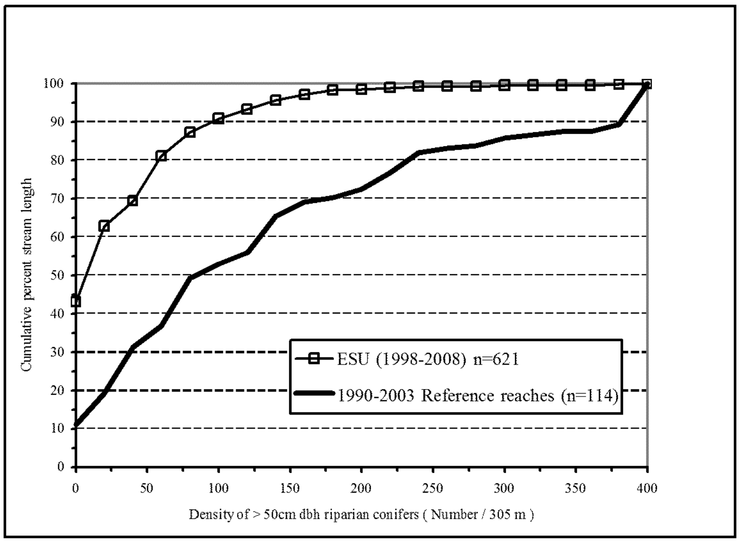
Appendix Figure A-9. Cumulative frequency distribution comparing slack-water pool habitat to reference conditions within coastal ESU, strata, and land use.

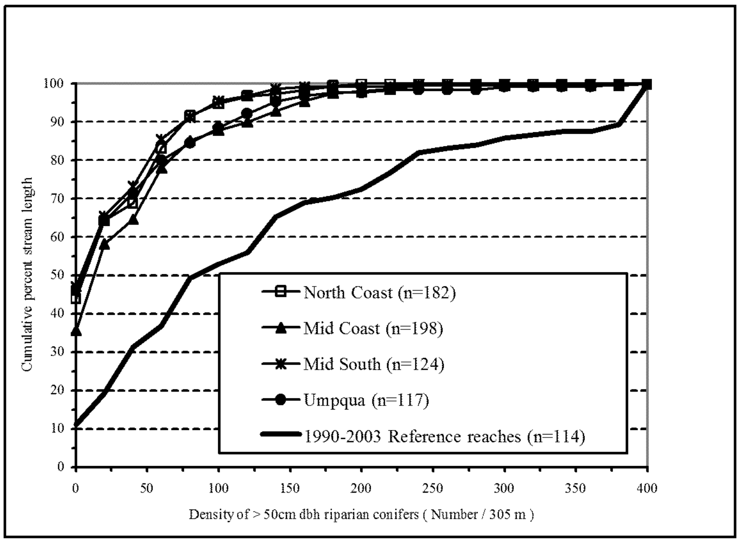


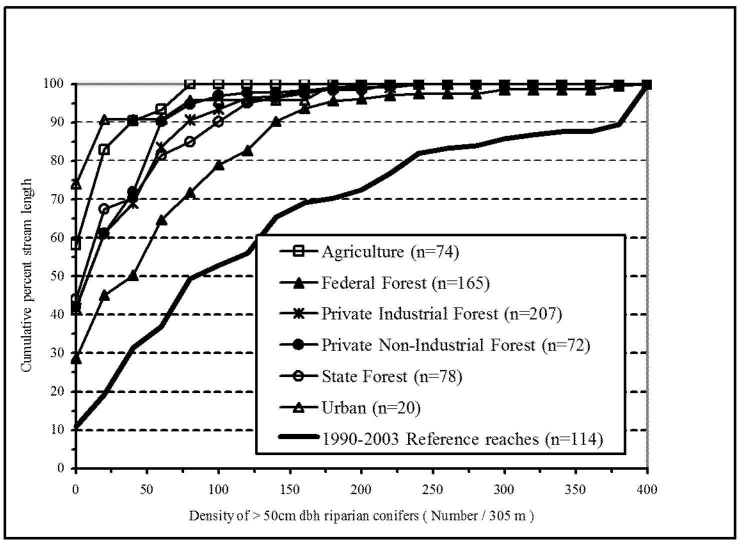




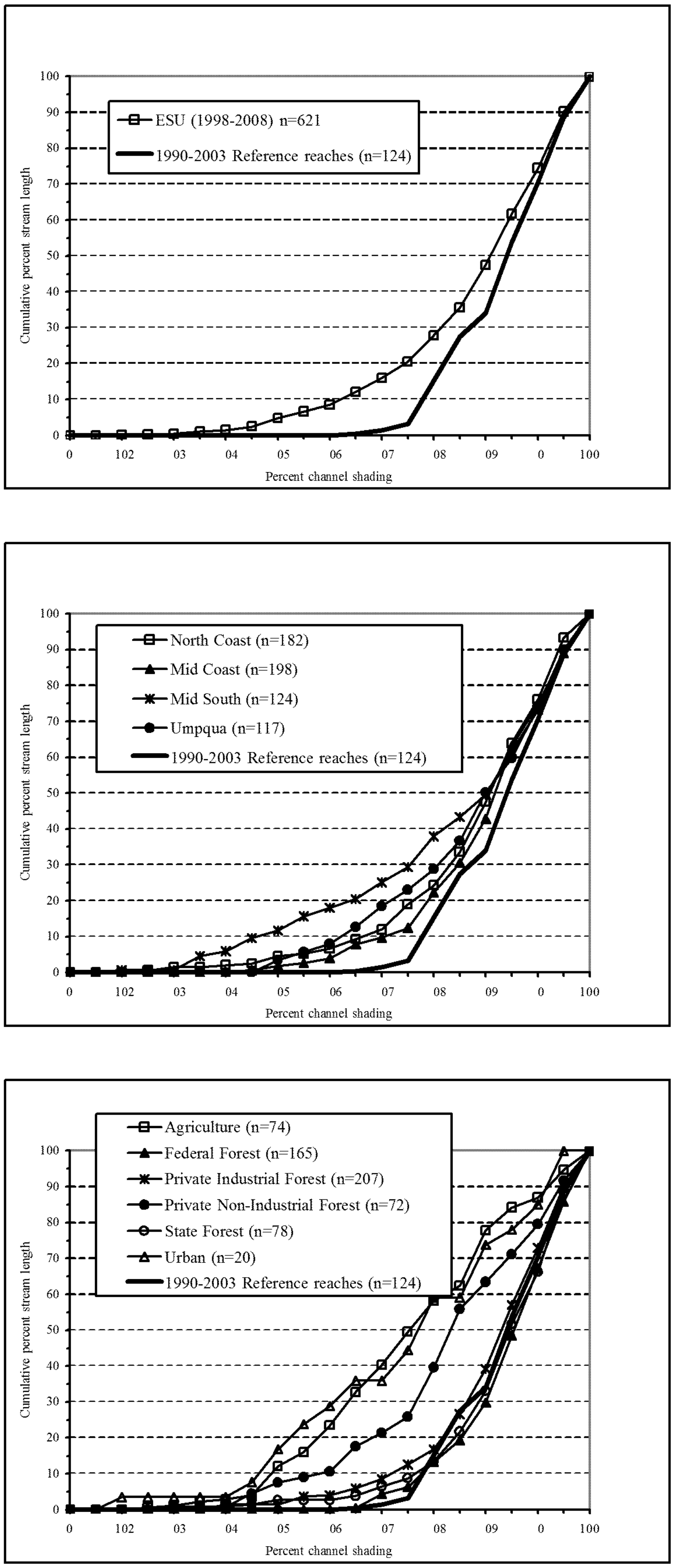
Appendix Figure A-10. Cumulative frequency distribution comparing total riparian conifers to reference conditions within coastal ESU, strata, and land use.



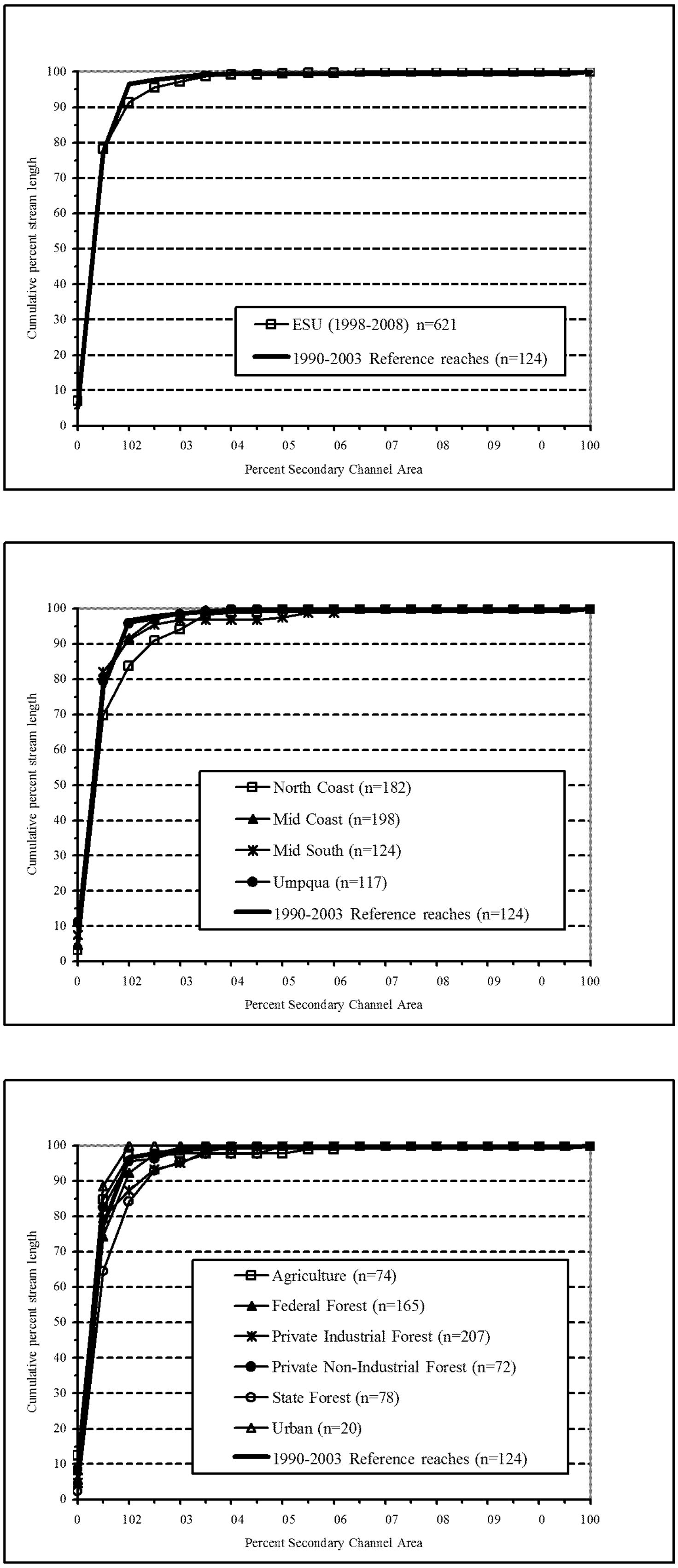




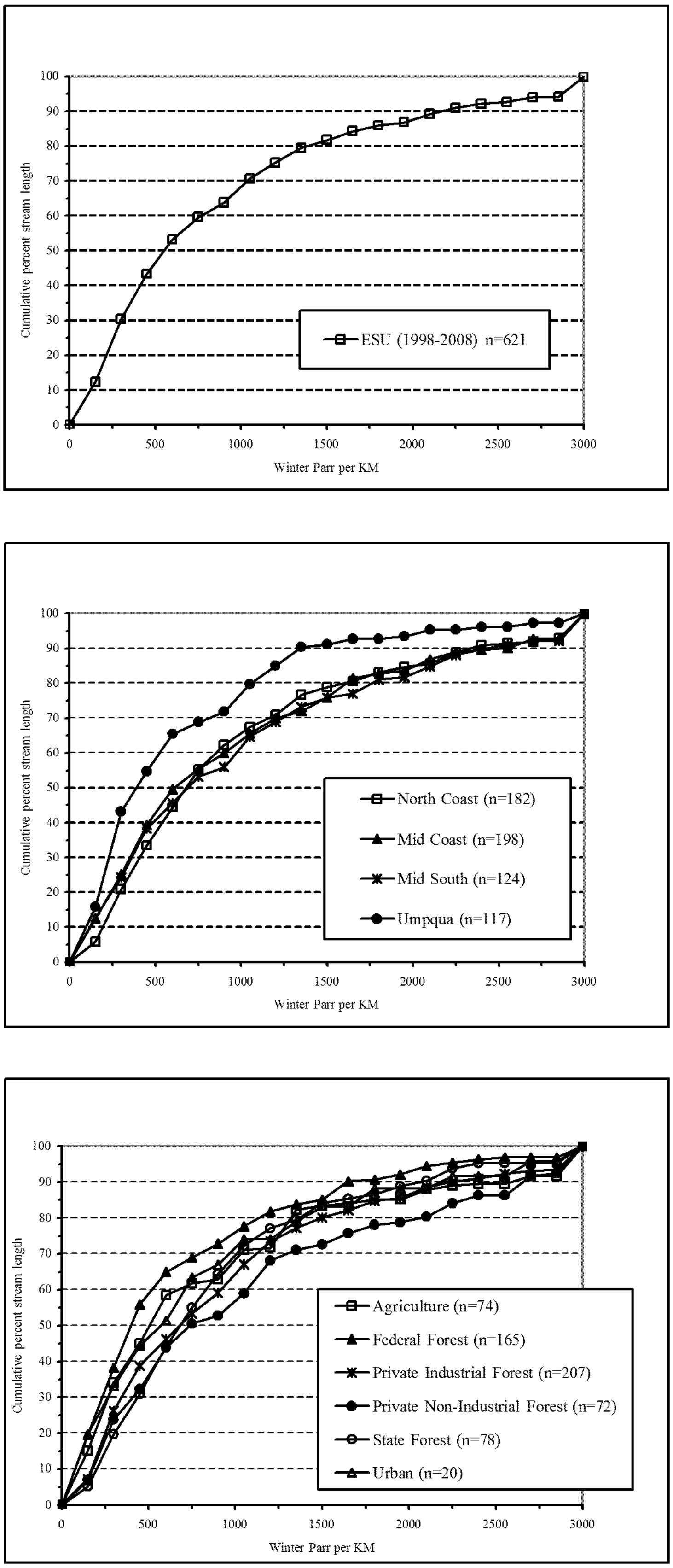
Appendix Figure A-11. Cumulative frequency distribution comparing large riparian conifers to reference conditions within coastal ESU, strata, and land use.



Appendix Figure A-12. Cumulative frequency distribution comparing canopy shade to reference conditions within coastal ESU, strata, and land use.



Appendix Figure A-13. Cumulative frequency distribution comparing secondary channel area to reference conditions within coastal ESU, strata, and land use.



Appendix Figure A-14. Cumulative frequency distribution comparing winter parr capacity within coastal ESU, strata, and land Use (NOTE: less than 900 is considered low and greater than 1850 is considered high).